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Kahanec, M.

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Social Interaction and the Labor Market: Essays on Earnings Inequality, Labor Substitutability, and Segregation

Social Interaction and the Labor Market: Essays on Earnings Inequality, Labor Substitutability, and Segregation

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de Universiteit van Tilburg, op gezag van de rector magnificus, prof. dr. F.A. van der Duyn Schouten, in het openbaar te verdedigen ten overstaan van een door het college voor promoties aangewezen commissie in de aula van de Universiteit op vrijdag 17 februari 2006, om 10:15 uur door

MARTIN KAHANEC,

geboren op 28 april 1977 te Rožňava, Slowakije.

Committee:

Supervisor:	**Prof. dr. J. C. van Ours, Tilburg University**
Co-supervisor:	**Assoc. Prof. dr. J. A. Smulders, Tilburg University**
Members:	**Prof. dr. J. Boone, Tilburg University**
	Prof. dr. A. B. T. M. van Schaik, Tilburg University
	Prof. dr. J. Hartog, University of Amsterdam
	Prof. dr. J. Ortega, London School of Economics

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Martin
December 2005
Bonn

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Chapter 1

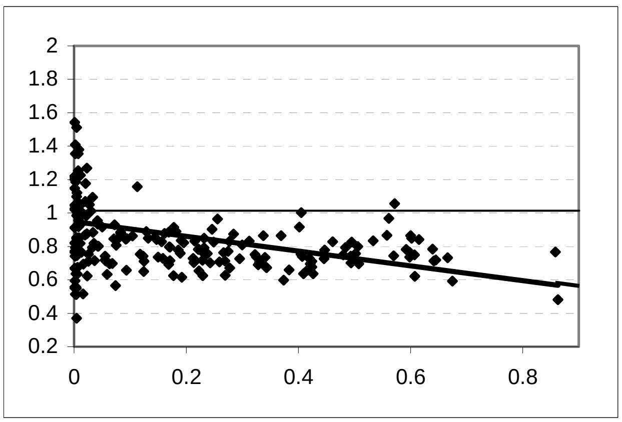
Introduction and Overview of the Thesis

1.1. Motivation and Purpose

The history of the mankind, be it ancient or just unfolding, involves a countless number of events that forcefully drove people from one place to another, often across national borders. Slave traffic, wars and revolutions, and natural catastrophes are all examples of such dreadful events. Perhaps even greater numbers of people migrate across national borders for social and economic reasons, including a more secure job, higher pay, or family reunion. Sometimes people did not physically move, yet they or their environment changed such that they emerged as a new social group within a state. Indeed, history abounds with episodes of dissemination of religions and languages and changes of state borders. All these events have resulted in a world where social and economic interaction of minorities and majorities is the rule rather than exception. African-Americans in the US, Turks in Germany, Roma in Central and Eastern Europe, and Muslims in the Netherlands are all examples of minorities in societies predominantly populated by majority people that are different in terms of language, religion, and other socio-cultural characteristics. More formally, we define minority as a particular racial, ethnic, language, or religious group of people who share socio-cultural characteristics such as culture, religion, language, history, beliefs, customs, values, and morals that make them distinct from the rest of the population – the majority – in their habitat. Thus, social groups formed on the basis of occupation, wealth, or other ordinal characteristics of this kind are not considered as minorities. While there may be regions where minority individuals outnumber majority individuals, minorities typically constitute a smaller proportion of population than majorities.

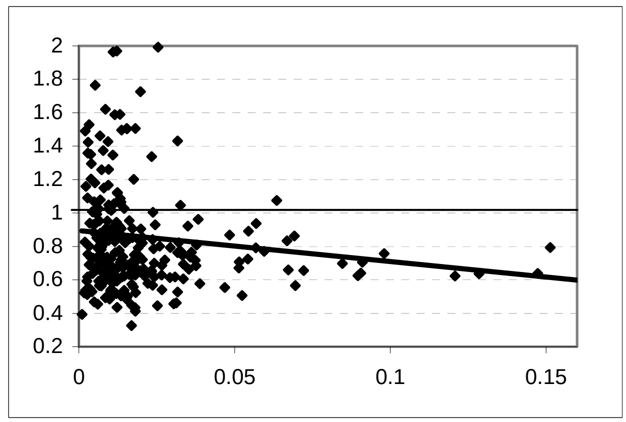
Interaction between ethnic groups exhibits several puzzling phenomena that intrigue social scientists and economists in particular. The first such phenomenon that I investigate in this thesis is what I denote the *scale puzzle*. It involves two empirical regularities. On the one hand, minorities typically earn less income per capita than majorities. On the other hand, minority-majority earnings disparity increases in the relative size of the minority in a region. The puzzling feature of these empirical regularities taking place at the same time is that while being a member of the smaller social group in a region, the minority, is disadvantageous in terms of earnings, minority people are relatively better off in regions where they are relatively less numerous. To illustrate these regularities, Figure 1.1 and Figure 1.2 plot Black-White and Hispanic-White ratio of median earnings of full time workers against the percentages of Blacks and Hispanics, respectively, over 310 Californian school districts. These two figures exhibit the two observations involved in the scale puzzle. First, in most school districts minority workers earn less than majority workers. Second, the linear trendlines fitted onto the data indicate that the earnings gap is increasing in minority percentage.

Figure 1.1: Black-White ratio of median per capita earnings as a function of Black percentage.



Source: Census 2000 School District Tabulation (STP2), NCES, US.

Figure 1.2: Hispanic-White ratio of median per capita earnings as a function of Hispanic percentage.



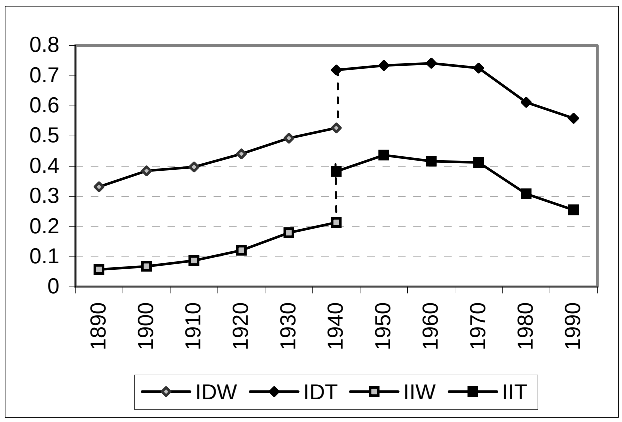
Source: Census 2000 School District Tabulation (STP2), NCES, US.

There is a large body of more formal evidence concerning the scale puzzle. The early empirical studies on this topic include Blalock (1956, 1957), Heer (1959), Brown and Fuguitt (1972), and Frisbie and Neidert (1977). For example, Heer (1959) finds a correlation of -0.71 between the ratio of Black and White median per capita incomes and the percentage of Blacks. Frisbie and Neidert estimate the correlations between minority-majority income disparity and minority share in the population between 0.19 and 0.70. They go as far as to conclude that "one of the most consistent findings … is that socioeconomic differentials vary directly with the relative numbers of a minority present in a given area …".[1] More recently, in a micro-econometric study about the earnings of Black, Hispanic, Asian, and White men in the US, Tienda and Lii (1987) establish the existence of significant minority-majority income differentials and confirm that minority labor market percentages favor the majority while disadvantaging the minorities themselves. Focusing on migrants, Borjas (1987) and Chiswick and Miller (2005) show that earnings of

[1] Frisbie and Neidert (1977), p. 1007

immigrants from a certain linguistic or ethnic group are decreasing in the concentration of similar people in the destination region. Based on these studies, the scale puzzle that (i) minority individuals on average earn less than majority individuals and that (ii) this earnings differential is increasing in minority share in population in a given region is taken as a stylized fact of minority-majority earnings inequality.[2]

Figure 1.3: Dissimilarity and isolation indexes 1890-1990. Native-born Blacks.



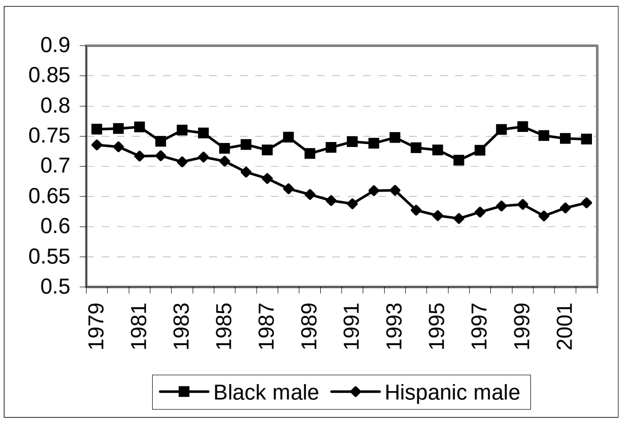
Source: Cutler et al. (1999), Table A.1. IDW: Index of dissimilarity at ward level. IDT: Index of dissimilarity at census track level. IIW: Index of isolation at ward level. IIT: Index of isolation at census track level. All unadjusted. Data of both methodologies available in 1940.

The second intriguing empirical phenomenon of minority-majority social and economic interaction that I investigate in this thesis concerns *segregation and income inequality*. A major development in cohabitation of Blacks and Whites in the U.S. was the reversal of segregation trends in the late seventies and desegregation of the Black minority thereafter.[3] In particular, while the first three quarters of the 20th century can in general be characterized by increasing degree of segregation, the last quarter witnessed a steady decline in the degree of segregation of the Black minority. This trend of desegregation after the 1970s is evidenced by e.g. Massey and

[2] Table 3A.1 in the Appendix of Chapter 3 summarizes this evidence in greater detail.
[3] Segregation is understood as separation of people according to their social, ethnic, racial, religious, or other characteristics in social interaction. Some of the most visible forms of segregation are geographical segregation, as exhibited by e.g. racial segregation of neighborhoods, and social segregation, as found in segregated schools or workplaces. The segregation literature is immense, including DuBois (1899), Myrdal (1944), Taeuber and Taeuber (1965), Massey and Denton (1987, 1993), and Farley and Frey (1994).

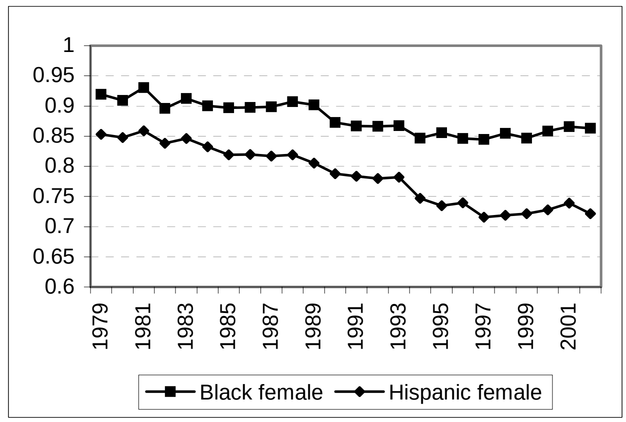
Denton (1987), Farley and Frey (1994), and Cutler et. al (1999).[4] Figure 1.3 depicts segregation trends for native-born Blacks. One can observe that index of dissimilarity and index of isolation[5] between native-born Blacks and Whites exhibit the same pattern: both are increasing until the 1960-70s and exhibit a steady decline thereafter.

Figure 1.4: Relative median usual weekly earnings of full-time wage and salary male minority workers in constant (2002) dollars, relative to white male, 1979-2002 annual averages.



Source: Current Population Survey, U.S. Department of Labor, Bureau of Labor Statistics

Figure 1.5: Relative median usual weekly earnings of full-time wage and salary female minority workers in constant (2002) dollars, relative to white female, 1979-2002 annual averages.



Source: Current Population Survey, U.S. Department of Labor, Bureau of Labor Statistics

Contrary to the commonsensical understanding that desegregation and lessening of inequality come hand in hand, during the same period the socioeconomic gap between ethnic and racial groups has been widening. In particular, as demonstrated by Altonji and Blank (1998), following a period of catching up during the 1960s, earnings gaps among racial and ethnic groups have been on the rise since the mid-1970s. More specifically, while Black men reduced and Black women almost closed the earnings gap during the 1960s when certain laws against labor market discrimination were adopted,[6] the relative earnings of Black men stagnated or somewhat deteriorated and the relative wages of Black women clearly declined since the 1970s, as

[4] The evidence is less clear for Hispanic and Asian minorities, largely due to sizeable recent immigration. See Massey and Denton (1987), Frey and Farley (1996), and Cutler et al. (2005).
[5] Indexes of dissimilarity and isolation are perhaps the two most widely used measures of segregation. The former tells us what share of the minority (or majority) population would need to relocate for the races to be evenly distributed. The latter measures the exposure of minority to majority. See Taeuber and Taeuber (1965), Duncan and Duncan (1955), and Bell (1954).
[6] See e.g. Heckman and Payner (1989), Donohue and Heckman (1991), and Neumark and Stock (2001)

compared to their White counterparts. Such deterioration was even more pronounced for Hispanic men and women.[7] Figures 1.4 and 1.5 depict trends in racial earnings inequality for Black and Hispanic workers vis-à-vis White workers by gender from 1979 till 2002. The general pattern one can observe is that the relative earnings of minority workers declined during this period.

The purpose of this thesis is to explain the aforementioned empirical puzzles and thereby further our understanding of the complexities of social and economic interaction of minority and majority people. The insights of this thesis are also intended to facilitate development of better-informed policies to systematically fight poverty and socio-economic deprivation, social exclusion, and segregation of many minorities that pose a heavy burden on racial relations. The premises on which the main arguments are based are elaborated in the next section.

1.2. The Elements

The old saying "tell me who your friends are and I tell you who you are" reflects the ancient wisdom that acquaintances matter. Undoubtedly, our acquaintances not only influence our social behavior, provide us with psychological comfort, and satiate our elementary need for social acceptance and recognition, but they also channel and interpret new information and knowledge to us. Moreover, whom we know determines what information and knowledge reaches us. Because information and knowledge typically have some value in the broad sense, the circle of persons with whom we interact affects our success in life. While this notion is at least as ancient as the saying mentioned above, it only slowly gained recognition of modern economists. In fact, it was a sociologist, Granovetter (1973, 1974), who was the first to study the role of social ties in accessing economic opportunities such as job openings.[8] Loury in his (1977) and (1981) articles was probably the first modern economist to challenge the purely individualistic paradigm prevalent in the economic analysis of that time, investigating the effects of social context on the achievement of minority and nonminority youth. Bourdieu (1986) systematized various forms of

[7] Altonji and Blank (1998), p. 3149.
[8] Of course, social interaction is the principal notion of sociology and social psychology. See Coleman (1960), Rapoport (1963), and Merton (1968).

capital and used the term *social capital* for the "aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition."[9] Bourdieu identified the role of social capital in the creation of human capital – attributes of a person, including skills, abilities, knowledge, and health, that are valuable on the labor market. This role was further investigated and formalized by Coleman (1988).

It was perhaps these developments outside the domain of mainstream economics that incited economists to treat the consequences of the embeddedness of individuals in social relations on economic outcomes more systematically. Several economists started to stress the role of social interaction in learning and human capital acquisition. Lucas (1988) argues that human capital acquisition involves social interaction in social networks. Building on the ideas of Allen (1982), Ellison and Fudenberg (1993, 1995) and Bala and Goyal (1998) theoretically investigate the role of social interaction in learning about optimal actions. Several empirical studies, including Valente (1995), Feick and Price (1987), Gladwell (2000), Foster and Rosenzweig (1995), Conley and Udry (2002), and Munshi (2002) substantiate that social interaction facilitates diffusion of information and is a vehicle of human capital acquisition. These studies suggest that individual investment, especially in terms of time and effort, in social interaction with friends, colleagues, classmates, relatives, and other acquaintances facilitates human capital acquisition. As a corollary, an individual benefits from an additional acquaintance and, correspondingly, whenever she joins a social network the incumbent members benefit from her joining. Indeed, Glaeser et al. (2002), Foster and Rosenzweig (1995), and Lazear (1999), maintain that social interaction in social networks often involves such positive spillover effects. [10] More formally, the first key premise of this thesis is that the benefits of an individual from social interaction are increasing in the number of people with whom this individual shares information and knowledge in social interaction.

While people's sets of acquaintances largely result from their choice, individuals are born into the social environment of their parents. This inherited social context, such as belonging to some

[9] p. 248

[10] Inefficiencies stemming from the size of social networks, such as inefficient herding, status, and congestion, are certainly possible. The focus of this thesis is on the benefits from social interaction in social learning, however.

ethnic group, affects their preferences as concerns their acquaintances to a significant extent. For instance, an individual born to Chinese parents and raised in the Chinese community of New York can be expected to have certain preference for socializing with other Chinese individuals with whom she shares language and other cultural and social characteristics. More formally, Poole (1927) and Lazear (1999) contend that small social distance between individuals, including common culture and common language, facilitates their social interaction. Schelling (1971) argues that even mild preferences to interact with individuals from one's own social group suffice to produce extensive segregation. Residential segregation of ethnic groups has been extensively studied and documented, including the works of DuBois (1899), Myrdal (1944), Massey and Denton (1987, 1993), Farley and Frey (1994), and Cutler et al. (1999). That individuals prefer to interact with similar people is the second key premise of this thesis.

In the following section I outline the organization and depict the main arguments of this thesis, highlighting the role of the two key premises therein.

1.3. Outline of the Thesis

The economic consequences of, first, the positive role of social interaction in human capital acquisition and, second, segregation of social networks along ethnic, racial, religious, or linguistic lines is the main subject of this thesis. The analytical part of this thesis begins with Chapter 2, where I depict an archetypal model of minority-majority interaction in human capital acquisition and in the labor market. This model serves to highlight the main variables and arguments of the thesis in a stylized framework. Moreover, the role of local effects and social distance in social interaction, as well as the key relationships they generate between organization of social interaction, inputs, and wages, are previewed.

Two fundamental relationships arise in this archetypal model. The first relationship, which I denote the efficiency effect, arises between relative social group sizes and their relative efficiencies of human capital acquisition. The efficiency effect arises as a direct consequence of the two key premises mentioned above. This effect favors larger social groups in terms of efficiency of human capital acquisition. Intuitively, a member of a larger social group has a relatively large pool of members of her own social group with whom she can socially interact in human capital acquisition without being obstructed by social distance between members of different social groups. In contrast, the chance that a member of a smaller social group is obstructed by social distance is relatively higher, since there is only a relatively small number of socially similar people of his own group. Therefore, although social distance is symmetric on the micro level, that is, individual A is as socially distant from individual B as is individual B from individual A, it generates asymmetry on the aggregate level.

The second relationship, denoted the substitution effect, arises between relative social group sizes and relative wages. The substitution effect is due to the textbook economic law that scarcer resources sell at higher price. It favors smaller social groups in terms of relative wage per efficiency unit of labor. Intuitively, due to their small relative number and thus relatively small supply of their type of human capital, members of a smaller social group earn higher relative wages than members of a larger social group. Moreover, as a result of the efficiency effect mentioned above, members of a smaller social group have relatively less human capital. This further decreases the aggregate supply of their type of human capital on the labor market, increasing their relative wage per efficiency unit of labor all the more. The fundamental prerequisite for the substitution effect to arise, however, is that there is imperfect substitutability between human capitals of minority and majority people, that is, that the types of human capital acquired by minority and majority individuals are generally different.

The key insight of the next chapter is that imperfect substitutability between human capitals of minority and majority people is a direct consequence of local spillover effects in human capital acquisition and minority-majority social distances in social interaction. In Chapter 3 I establish that in a world where heterogeneous skills are available in skill-specific social networks the efficiency differentials engendered by these local effects and social distance systematically expose minority and majority individuals to different incentives as concerns their choice of skills. As a result, depending on the equilibrium organization of skill acquisition, minority and majority individuals have different sets of acquaintances, acquire different (combinations of) skills, and are imperfect substitutes on the labor market.

In regard of the empirical regularities depicted in Section 1.1, Chapter 3 elucidates the socio-economic mechanisms behind the scale puzzle. In the model of Chapter 3, besides the abovementioned substitution effect, local spillover effects in human capital acquisition and minority-majority social distance give rise to the efficiency effect that disadvantages minorities in terms of efficiency of human capital acquisition, similarly as in Chapter 2. The conditions under which the efficiency and substitution effect explain the scale puzzle are established. In addition, this chapter offers an answer why some minorities earn more than majorities, why minority individuals tend to spend more time socializing in families than in schools, and why integration may harm minorities.

The key argument of this chapter reconciles the literature represented by e.g. Benabou (1993, 1996), Durlauf (1994, 1996), Steele (1992), Akerlof (1997), and Lundberg and Startz (1998), who explain earnings differences across social groups as a consequence of local spillover effects involved in agents' social environment, with the scale puzzle. In particular, a standard argument based on local effects in human capital acquisition predicts that such local effects engender efficiency disadvantage of relatively small social groups. According to such argument minorities earn less than majorities but, contrary to empirical evidence, the earnings gap is decreasing in minority size. The main contribution of Chapter 3 in this respect is that it establishes that local spillover effects in human capital acquisition engender qualitative differentiation of minority and majority human capitals, which generates the substitution effect as depicted above. It is this substitution effect that explains why larger minorities earn relatively less than smaller ones. No taste-based discrimination in the labor market is necessary to obtain the results of this chapter, which makes the argument of this chapter an alternative to the existing Becker-type taste-based discrimination theories of earnings inequality. [11]

In brief, in Chapter 3 I argue that the positive relationship between minority percentage and minority-majority earnings gap is a labor market phenomenon that arises as a consequence of

[11] See Altonji and Blank (1999), pp. 3170-3176, for a discussion of these theories. Main contributions include Becker (1957 and 1971), Welch (1967), and Arrow (1972a, 1972b, 1973). Note also that social distance may be understood as a form of taste discrimination in social interaction. In any case, the mechanisms behind the key results of Chapter 3 are very different from those in the taste-based discrimination literature.

imperfect substitutability of minority and majority labor. Chapter 4 empirically investigates this proposition using data from the US labor market. I adopt the framework of a generalized Leontief production function,[12] which permits estimation of cross elasticities of complementarity among a number of minorities.[13] In addition, I estimate a model of labor market competition in which I assume a constant elasticity of substitution between minority and majority workers. The analysis rejects the null hypothesis that minority and majority labors are perfectly substitutable in the labor market. In particular, it is established that minority workers complement majority workers in production and vice versa and that the elasticity of substitution between minority and majority workers is finite. In effect, Chapter 4 supports the theory that minority and majority labors are different as concerns the type of skills they entail. Furthermore, it suggests that the empirical evidence that relative earnings of minority individuals decrease in the percentage of minority individuals in a given region is a labor market outcome.

The analysis of Chapter 4 shows that imperfect substitutability is not only a characteristic of immigrant and native labors, as argued by e.g. Grant and Hamermesh (1981), Grossman (1982), and Borjas (1987), but also that labor of the White majority and the Black, Asian, and other minorities is imperfectly substitutable. As compared to the study of Borjas (1983), who studies Black, Hispanic, and White labor, this study analyses aggregated data at the levels of the school district and county and considers a different partition of labor supply, involving Asian, American Indian, and Pacific Islander communities.

In the last chapter of this thesis I elucidate the two seemingly contradicting developments in the lives of minority and majority Americans witnessed by the last quarter of the 20th century: (i) the desegregation of the Black and (ii) the increasing interethnic earnings inequality. While in Chapter 2 and Chapter 3 the labor market distinguished minority and majority workers, in Chapter 5 I adopt a different premise: labor market distinguishes segregated and integrated workers, regardless of their ethnicity. In this framework, I study the decision of individuals with whom to socially interact. Specifically, I investigate the choice of minority individuals between integration and segregation, that is, their decision whether to interact with both majority and

[12] Diewert (1971)
[13] Hicks (1970)

minority individuals or to restrict themselves to interaction with minority people. Further, I study the role of the advancement of information and communication technologies (ICT) on this choice and clarify how it explains the empirically established regularities of increasing earnings inequality and desegregation.

As it is the case throughout the thesis, the main argument of Chapter 5 is based on the premises that social interaction facilitates human capital acquisition and that individuals prefer to interact with similar people. Given these premises, the decision of a minority individual to integrate or segregate involves the efficiency aspect: segregation entails social interaction with a restricted number of similar people while integration allows a minority individual to socially interact with a relatively large number of socially distant majority people. Moreover, in this chapter an explicit account is taken of the premise that the composition of the set of one's acquaintances determines the type of information that reaches her and thus the type of her human capital. In the context of Chapter 5 this premise implies that choosing between segregation and integration matters not only for the quantity but also the type of one's human capital. As a first step in the argument of this chapter, it is established in a general equilibrium model that these premises imply a non-degenerate equilibrium degree of segregation of the minority.

ICT advancement is an important factor that affects this equilibrium. Indeed, social interaction is the primary vehicle through which advancement of ICT affects socio-economic outcomes. In particular, I argue that ICT advancement typically disproportionately increases the efficiency of (i) social interaction in integrated social networks and (ii) majority individuals, thereby causing desegregation and increasing interethnic earnings inequality at the same time. Chapter 5 thus resolves the second empirical puzzle of this thesis and elucidates why the concurrence of desegregation and increasing earnings inequality is not coincidental. Namely, it establishes that the ICT revolution has two faces in the context of racial relations: it contributes to desegregation of minority people and drives a wedge between minority and majority earnings.

Furthermore, in Chapter 5 I establish that there is a threshold level of ICT below which all minority individuals chose segregation and above which some but not all minority individuals chose integration, reaping the efficiency benefits of social interaction with a relatively large number of majority individuals. I argue that the reversal of the segregation trend that occurred in the late 1970s was a consequence of ICT's passing this threshold level. Finally, I show that a substantial advancement of ICT may be necessary to cause desegregation in case of a very high degree of initial segregation and that ICT advancement may actually reinforce segregation of minorities that are particularly dissimilar to the majority. These theoretical results provide an explanation of why typically no desegregation occurred in extraordinarily segregated areas [14] and in the case of recent immigrants, [15] who are typically more dissimilar with respect to majority population than native-born minorities.

1.4. The Contribution of the Thesis and Suggestions for Further Research

This thesis aims at providing new insights into the complex world of social and economic cohabitation of different ethnic groups, minorities and majorities. Perhaps the four most important findings of this thesis are the following. First, differences in the type of skills and the quantity of human capital acquired by minority and majority people arise as a consequence of local spillover effects and minority-majority social distance in human capital acquisition. On that account, these differences are a systematic feature of minority-majority cohabitation. In particular, so long as minority-majority social distance remains positive such that these social groups are well defined, there are social and economic mechanisms that perpetuate these differences and their consequences, including the positive relationship between minority-majority earnings differential and minority relative size.

Second, while integration of minority people benefits everybody in terms of efficiency of human capital acquisition by removing the inefficiencies introduced into the exchange of ideas and knowledge by segregation, it may increase earnings inequality between minority and majority people. The reason is that the set of primary competitors of integrated minority individuals on the

[14] As evidenced by Cutler et al. (1999)
[15] Cutler et al. (2005) provide evidence that segregation of recent immigrants has actually been increasing. They suggest that this finding is due to the increasing dissimilarity between recent immigrants and native-born population, as contrasted to earlier immigration.

labor market is larger than that of segregated minority individuals. Specifically, segregated minority individuals mainly compete with other segregated minority individuals on the labor market, whose number is small relative to total population. On the other hand, minority people who are integrated acquire skills more similar to those of majority people. Therefore, the set of their primary competitors involves majority individuals, whose number is relatively large. As a result, although integration facilitates human capital acquisition, it exposes minority individuals to more intense competition that lowers their wage per efficiency unit of labor. If integration lowers minority relative wage more than it increases its relative efficiency of human capital acquisition, integration widens minority-majority earnings gap.

Third, empirical analysis of Chapter 4 validates the view that minority and majority labor is not perfectly substitutable in production. In fact, the results also indicate that minority and majority labor is complementary in production. If so, however, the widespread fear of majority people that minority workers take their jobs is groundless. In fact, there are benefits to multiethnic labor force in production and majority people benefit from presence of minority co-workers.

Finally, this thesis explicates the benefits and costs of advancement of information and communication technologies. Specifically, advancement of ICT increases the efficiency of human capital acquisition, thereby benefiting everybody. Furthermore, it causes desegregation of minority individuals, since the benefits of efficiency improvement are more pronounced in integrated social environments. However, the effects of ICT advancement are asymmetric for minority and majority individuals as concerns their efficiency of human capital acquisition. In particular, ICT advancement favors the majority and thereby enlarges the minority-majority earnings gap.

A number of new directions for research arise in this thesis that are worth mentioning here. First, it is worth studying social distance as a variable of individual choice. While many social and cultural characteristics are transferred from parents to children, individuals may decide to adopt or reject social and cultural features of other social groups and to keep or forgo some features of their own culture. For example, a minority individual may decide to learn the language of the majority, to stick to his or her religion, or to embrace minority’s social norms. This choice can be expected to have important repercussions for individual success on the labor market and thus for earnings inequality. Moreover, social distance affects individual choices as concerns social interaction and is itself affected by these choices. For instance, social distance affects minority's incentives to integrate and integration is likely to decrease social distance. It is therefore also interesting to study the dynamics of social distance in relation to the dynamics of organization of social interaction.

Second, further empirical work is desirable. In the view that most empirical evidence about the empirical regularities presented in this thesis concerns the US, there is the need to investigate the robustness of the reported evidence using data from outside the US, including Europe. Furthermore, it would be interesting to empirically investigate and measure the effects of ICT advancement on the organization of social interaction and segregation in particular.

Finally, in the context of the last chapter it would be extremely interesting to investigate ICT advancement as an endogenous process. In particular, ICT technologies not only facilitate social interaction but their adoption is, as is the case for other technologies as well, a function of the efficiency of social interaction. This relationship is of general concern, but particular implication may arise in the context of minority-majority cohabitation. For example, a study of adoption of ICT technologies may yield several insights about (the dynamics of) interethnic earnings inequality.

Chapter 2

Social and Economic Interaction between Minority and Majority People: An Archetypal Model

2.1. Introduction

In this introductory chapter I develop an archetypal model of minority-majority interaction in human capital acquisition and in the labor market that paves the way to the models of Chapter 3 and Chapter 5. This model brings to light the key variables and relationships previewed in the introductory chapter. In particular, I highlight two key effects of the relative size of minority on its relative earnings. First, through the *substitution effect*, which is a direct consequence of the textbook law of diminishing marginal returns, relatively larger minorities earn relatively less per efficiency unit of their labor. Second, through the *efficiency effect*, social distances and local spillover effects in skill acquisition cause relatively smaller minorities to be relatively less efficient in human capital acquisition. As a result, relatively smaller minorities acquire relatively less human capital. The last sections of this chapter relate the model developed in this chapter to the models of Chapter 3 and 5.

2.2. The Model

2.2.1. Demand

To start with the demand side, consider an economy populated by the continua of minority and majority individuals with measures I and J and elements i and j, respectively. The size of the economy is conveniently normalized to unity such that $I + J = 1$. Social distance between minority and majority individuals marks the distinction between minority and majority social groups. Individual membership in one of the two social groups is predetermined for each individual. Except for group membership and social distance, all individuals are identical with respect to their preferences and endowments. Individual preferences are represented by a standard utility function $u(\cdot)$ defined on individual consumptions of the consumption good, C_k, where $k \in \{i, j\}$.

Let the consumption good be produced by combining labor of minority and majority individuals, H_i and H_j, respectively, according to the aggregate production function:

$$C = F\left(H_I, H_J\right), \tag{2.1}$$

where $H_I = \int_0^I H_i di$ and $H_J = \int_0^J H_j dj$. It is assumed that this production function exhibits standard properties: positive marginal product of each input, concavity, and constant returns to scale (CRS). Assuming that production takes place in a perfectly competitive industry, wages equal marginal productivities and thus $W_i = F_{H_I}$ and $W_j = F_{H_J}$, from which it follows that

$$\frac{W_i}{W_j} = \frac{F_{H_I}}{F_{H_J}}. \tag{2.2}$$

The following proposition states that if the production technology (2.1) is symmetric with respect to minority and majority labor inputs, the social group that supplies more labor earns a lower wage per unit of labor and vice versa. This is a version of the elementary economic law of diminishing marginal product that implies that scarcer resources sell at higher prices, ceteris paribus.

Proposition 1

Whenever the CRS production technology (2.1) is symmetric such that $F(H_I, H_J) = F(H_J, H_I)$ for every H_I and H_J and satisfies the properties $F_{H_I} > 0$, $F_{H_J} > 0$, $F_{H_I,H_I} < 0$, and $F_{H_J,H_J} < 0$, $H_I \gtreqless H_J$ implies $W_i \lesseqgtr W_j$.

Proof:

That $F(H_I, H_J) = F(H_J, H_I)$ for every H_I and H_J implies $F_{H_I} = F_{H_J}$ whenever $H_I = H_J$. If $H_I > H_J$, $F_{H_I,H_I} < 0$ and $F_{H_J,H_J} < 0$ imply that $H_I < H_J$, and vice versa. ■

An important and natural assumption that I make is that an increase in the supply of minority (majority) labor depresses minority (majority) wage relatively more than it depresses majority (minority) wage. Specifically, I assume that cross partial elasticity of complementarity is smaller than own partial elasticity of complementarity[1], or, formally,

$$\frac{FF_{H_I,H_I}}{F_{H_I}F_{H_I}} < \frac{FF_{H_J,H_I}}{F_{H_J}F_{H_I}} \tag{2.3a}$$

and

[1] See Hicks (1970). The Hicks elasticity of complementarity measures the effect on the relative price of a given factor of production of a change in the relative quantity of that factor, holding marginal costs and the quantities of other factors constant.

$$\frac{FF_{H_J,H_J}}{F_{H_J}F_{H_J}} < \frac{FF_{H_I,H_J}}{F_{H_I}F_{H_J}}. \tag{2.3b}$$

Let us denote $w \equiv W_I/W_J$ and $h \equiv H_i/H_j$ and adopt the representative agent hypothesis group-wise, such that $H_I = H_i I$ and $H_J = H_j J$. It follows that $H_I/H_J = h(I/(1-I))$ and one can rewrite the relative wages (2.2) as a function of relative labor supplies

$$w = w(h, I). \tag{2.4}$$

In addition, let us assume that H_i and H_j, and thus *h* as well, are independent of *I*. Proposition 2 states the result that relative wages decrease in both the relative minority size *I* and minority-majority ratio of per capita supply of efficient labor *h*.

Proposition 2 (The substitution effect)

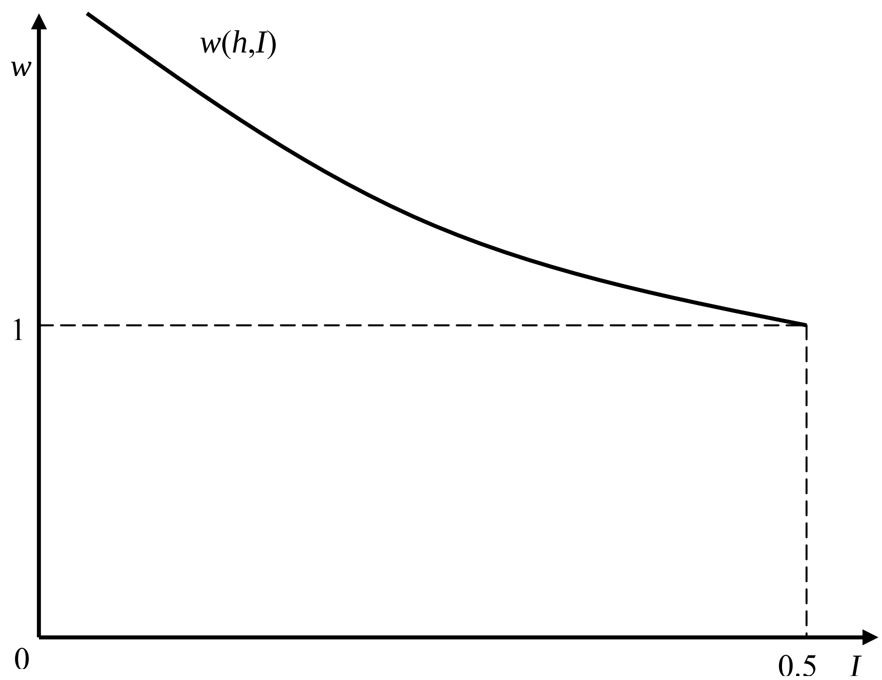
Whenever the production technology (2.1) satisfies conditions (2.3a-b) and *h* and *I* are independent of each other, $\partial w(h,I)/\partial h < 0$ and $\partial w(h,I)/\partial I < 0$.

Proof:

Conditions (3a-b) imply that $\frac{\partial(F_{H_I}/F_{H_J})}{\partial H_I} = \frac{F_{H_I,H_I}F_{H_J} - F_{H_I}F_{H_J,H_I}}{(F_{H_J})^2} < 0$ and $\frac{\partial(F_{H_I}/F_{H_J})}{\partial H_J} = \frac{F_{H_I,H_J}F_{H_J} - F_{H_I}F_{H_J,H_J}}{(F_{H_J})^2} > 0$, that is, relative wage of minority individuals relative to the wage of majority individuals is decreasing in the supply of minority labor and increasing in the supply of majority labor. It follows, however, that relative wages are decreasing in relative labor supplies, that is, $\partial(W_I/W_J)/\partial(H_I/H_J) < 0$. By definition, $\partial(H_I/H_J)/\partial h > 0$ and $\partial(H_I/H_J)/\partial I > 0$. It follows that, given that *h* and *I* are independent of each other, $\partial w(h,I)/\partial h < 0$ and $\partial w(h,I)/\partial I < 0$. ■

Intuitively, whenever an increase in the supply of a production factor depresses its own price more than the price of other production factors, an increase in the relative supply of a production factor depresses its relative price. Proposition 2 brings to light the first of the two key relationships that are elaborated in Chapters 3 and 5: the substitution effect. Through this effect, holding per capita supply of labor constant, relatively larger minorities suffer from the relative abundance of the their labor in the labor market that depresses the relative wage per unit of their labor. Figure 2.1 depicts the substitution effect with respect to *I*. The function $w(h,I)$ is decreasing in *I* and, recalling the result of Proposition 1 and assuming that $h = 1$, attains the value of 1 for $I = 0.5$.

Figure 2.1: The substitution effect.



2.2.2. Supply

In this section I characterize the supply side of the model. Specifically, I establish the relationship between the share of minority (majority) individuals in the labor market and their supply of labor. For simplicity, let us assume that each individual is endowed with one unit of labor time that is inelastically supplied on the labor market. An individual can, however, choose to acquire human capital and thereby increase the efficiency of a unit of his or her labor in production. Let us define efficient labor to be the measure of labor in efficiency units that comprises labor time and human capital.

Two assumptions concerning the supply of efficient labor are of key importance. First, there are local spillover effects in human capital acquisition. In particular, an individual benefits from social interaction that involves sharing knowledge and ideas with other individuals. By assumption, these benefits are increasing in the number of individuals any given individual is socially interacting with. Second, social distance between minority and majority individuals obstructs their social interaction in human capital acquisition. For simplicity, it is also assumed that social interaction takes place in economy-wide social networks – social structures between individual actors that facilitates social interaction among their members. Thus, any given individual interacts, possibly indirectly, with all other individuals, that is, I minority and J majority individuals. To capture the role of local spillover effects and social distance in human capital acquisition in an easily tractable way, I let the function $N(I, J, \delta)$ characterize the benefits from social interaction in human capital acquisition. The parameter δ captures the idea that the benefits from social interaction with majority (minority) agents decrease in social distance between minority and majority individuals. Given the assumptions above, $N(I, J, \delta)$ is increasing in *I* and *J* and decreasing in δ. Assumption that efficient labor is the product of labor time, which is fixed at unity, and human capital, individual supply of efficient labor equals:

$$H_i = 1 + N(I) + N(J/(1+\delta)) \tag{2.5a}$$

$$H_j = 1 + N(I/(1+\delta)) + N(J). \tag{2.5b}$$

That social distance between members of the same social group is normalized to zero is directly incorporated in specifications (2.5a-b). These functions imply that an individual who does not learn simply supplies his or her raw unit of labor time in the labor market. The following proposition states that local spillover effects in human capital acquisition and social distance between minority and majority individuals disadvantage smaller social groups in terms of efficiency of human capital acquisition.

Proposition 3 (The efficiency effect)

Given a positive social distance between minority and majority individuals δ and that $N(.)$ is increasing in its argument, technologies (2.5a) and (2.5b) imply that $\partial h(I)/\partial I > 0$ and, because $I < J$, $H_i < H_j$.

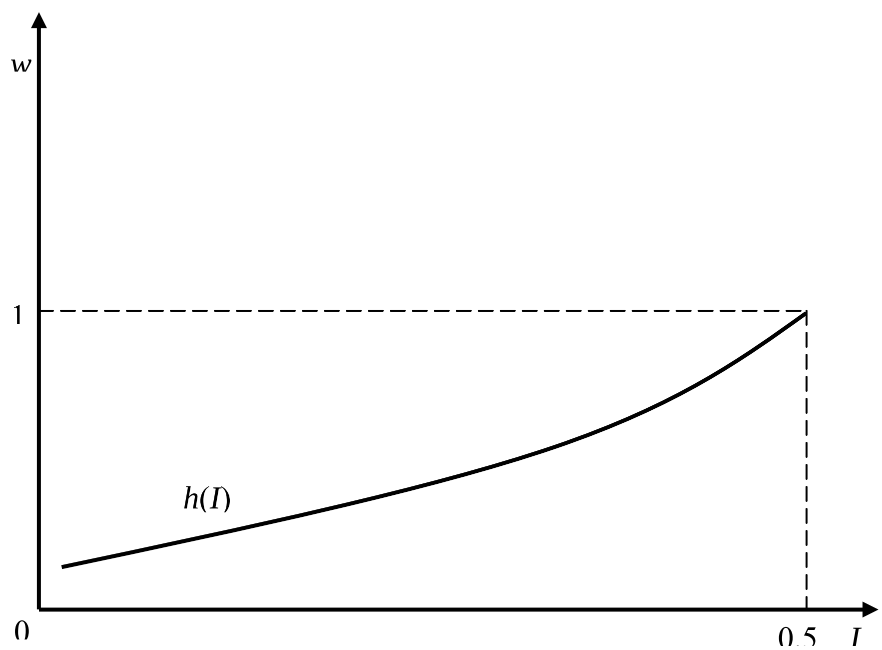
Proof:

$I+J=1$ implies that $H_i = N(I) + N((1-I)/(1+\delta))$ and $H_j = N(I/(1+\delta)) + N(1-I)$

Given this, $dH_i/dI = \frac{\partial N(I)}{\partial I} + \frac{\partial N((1-I)/(1+\delta))}{\partial((1-I)/(1+\delta))}\left(-\frac{1}{1+\delta}\right)$ which implies, noting that $N(.)$ is increasing in its argument, that $Sign(dH_i/dI) = Sign(1-1/(1+\delta))$, which is positive for any $\delta > 0$. Similarly $Sign(dH_j/dI) = Sign(1/(1+\delta)-1)$, which is negative for any $\delta > 0$. It follows that $\partial h/\partial I > 0$. Now note from (2.5a) and (2.5b) that $I = 0.5$ implies $h = 1$. Given that $\partial h/\partial I > 0$, for $I < 0.5$ it holds that $h < 1$, that is, $I < J$ implies $H_i < H_j$. ■

Proposition 3 exposes the second of the two key relationships of Chapters 3 and 5: the efficiency effect. Through this effect larger minorities are relatively more efficient than smaller ones in human capital acquisition. Intuitively, a member of a smaller social group has a relatively smaller pool of members of her own social group with whom she can socially interact without being obstructed by social distance. In effect, the chance that she is disadvantaged in social interaction by the inefficiencies engendered by social distance is relatively higher than that of a member of a relatively larger social group. Figure 2.2 depicts *h* as a function of *I*, which is upward sloping due to the efficiency effect and reaches unity at $I = 0.5$.

Figure 2.2: The efficiency effect.



2.2.3. Equilibrium

Sections 2.2.1 and 2.2.2 depicted the properties of the relationship between minority-majority wage and labor ratios, w and h, and minority percentage, I, as determined by the demand and supply sides, respectively. In this section I turn to the equilibrium properties of these relationships. Since h is independent of w, as apparent from Section 2.2.2, the equilibrium properties of h as a function of I are fully determined by the supply side and thus matching those presented in Proposition 3. Therefore, in the equilibrium, $h(I)$ is increasing in I.

As concerns the properties of the relationship between the minority-majority wage ratio and minority percentage in the equilibrium, these are determined by the supply side, as depicted in Proposition 2, but also by the demand side, as apparent from equation 2.4, where w is shown to be a function of h. We know from the demand side analysis of Section 2.2.1 that, taking h as independent of I, $w(h,I)$ is decreasing in each of its arguments. Section 2.2.2 tells us that h is an increasing function of I, however. Proposition 4 resolves the equilibrium relationship between w and I, establishing that Proposition 2 and Proposition 3 imply that minority-majority wage ratio is decreasing in minority percentage.

Proposition 4

Whenever the production technology (2.1) satisfies conditions (2.3a-b), $\delta > 0$, and that $N(.)$ is increasing in its argument, $\partial w(I)/\partial I < 0$.

Proof:

From Proposition 2, given the independence of h and I, conditions (2.3a-b) imply that $\partial w(h,I)/\partial h < 0$ and $\partial w(h,I)/\partial I < 0$. From Proposition 3, given $\delta > 0$ and that $N(.)$ is increasing in its argument, $\partial h(I)/\partial I > 0$. It is straightforward to see that $\partial w(h,I)/\partial h < 0$, $\partial w(h,I)/\partial I < 0$, and $\partial h(I)/\partial I > 0$ imply that $w(h(I),I) = w(I)$ is decreasing in I. ■

This result is quite intuitive. Due to the substitution effect, minority-majority relative wage decreases in minority share. An increasing share of minority people increases their efficiency in human capital acquisition through the efficiency effect such that per capita supply of efficient labor of minority people increases relative to the per capita supply of efficient labor of majority people. This increase further depresses minority-majority relative wage through the substitution effect. These are the fundamental relationships that determine the properties of one of the key variables of this thesis: the ratio of minority and majority earnings per capita, ω, which is, obviously, the product of *w* and *h*, that is, $\omega \equiv wh$. In the following sections I preview how the remaining theoretical chapters of this thesis draw on these relationships.

2.3. Earnings Inequality and the Substitutability of Minority and Majority Labor

The properties of the minority-majority earnings ratio as a function of minority percentage *I*, $\omega(I)$, are determined by the properties of the underlying functions, $w(I)$ and $h(I)$. Based on the results established in the previous sections, there are two opposing forces driving this relationship: the substitution and efficiency effects. In Chapter 3 I study earnings inequality in a greater depth and show that under some conditions these opposing effects generate patterns of earnings inequality consistent with the scale puzzle. Loosely speaking, these conditions need to secure that the substitution effect is not too strong relative to the efficiency effect such that minority individuals earn less than majority individuals and that it is strong enough such that minority-majority earnings differential is widening with minority percentage.

The extreme case of perfect substitutability between minority and majority workers points at an important insight of Chapter 3. Let us first note that perfect substitutability of minority and majority labors implies that $F_{H_I} = F_{H_J}$ in equation (2.2) and thus $W_I = W_J$, which in turn implies that $\omega(I) = h(I)$. From Proposition 3 we know, however, that $H_i < H_j$ and $\partial h(I)/\partial I > 0$. Thus, given that $\omega(I) = h(I)$, Proposition 3 implies that $\omega(I) < 1$ and $\partial \omega(I)/\partial I > 0$. The latter of these inequalities goes against the empirical evidence involved in the scale puzzle that relatively smaller minorities earn relatively more. In this respect, the fundamental insight of Chapter 3 is that local spillover effects and minority-majority social distance lead to organization of human capital acquisition that causes minority and majority people to acquire different types of human capital. In effect, minority and majority workers are not perfectly substitutable on the labor market and the substitution effect is effective. It is this effect that explains why relatively larger minorities earn relatively less than smaller ones.

2.4. Segregation and Earnings Inequality

Insofar it has been assumed that the labor market distinguishes two kinds of labor: minority and majority labor. Chapter 5 investigates an important departure from this assumption in order to study the effects of advancement of information and communication technologies on segregation and earnings inequality. In particular, minority individuals are permitted to integrate with majority individuals in social interaction such that the type of their human capital becomes similar to that of majority individuals. This assumption implies that social group sizes *as distinguished by the labor market* are endogenous. As a consequence, it has important consequences for the working of the labor market but also for the organization of human capital acquisition. First, by deciding to segregate or integrate, minority individuals are in essence choosing what kind of labor to supply and thus the wage per efficiency unit of their labor. Second, because segregation is a barrier to social interaction, minority individuals by choosing whether to integrate or not choose their efficiency of human capital acquisition. In effect, earnings of minority people are a function of their decision to segregate or integrate, since this decision affects the two determinants of their earnings: wage and human capital. Therefore, substitution and efficiency effects similar to those described above govern minority's choice to segregate or integrate.

To wit, the baseline model developed above can straightforwardly be reinterpreted to describe the choice of minority people to integrate or not. It suffices to redefine social groups on the labor market. More specifically, for the study of the choice of minority people to segregate or integrate the relevant social groups are, first, the group of people who are segregated and, second, the group of people who are integrated. In effect, there are two kinds of labor and the respective wages on the labor market: that of segregated minority individuals and that of majority individuals and those minority individuals who choose to integrate. So the production function (2.1) can be reinterpreted as a technology that combines labor inputs of integrated and segregated individuals. Similarly as in Proposition 2, one obtains that relative wage of segregated individuals is decreasing in the relative number of people who choose to segregate. Hence, people's switching between segregation and integration generates similar consequences for the distribution of earnings as the familiar substitution effect described above.

As concerns the organization of social interaction and human capital acquisition, segregation is a barrier to social interaction and thus the choice of minority to segregate and integrate involves an efficiency effect similar to that discussed in previous sections. The efficiency aspect of minority and majority social interaction depicted above closely resembles that of segregated and integrated minority individuals in the present context. In particular, an increase in the number of people who choose to segregate benefits (harms) segregated (integrated) minority individuals in terms of efficiency through enlarging (diminishing) their social networks. Therefore, human capital of segregated minority individuals relative to that of integrated ones is increasing in the relative number of minority people who choose to segregate.

In Chapter 5 it is shown that this framework is suitable for the study of the effects of advancement of information and communication technologies on the degree of segregation and minority-majority earnings inequality. In particular, it is shown that such improvement causes desegregation of minority individuals and increases interethnic earnings inequality, thereby explaining the concurrence of these two phenomena in since the 1970s in the US, as mentioned above.

Chapter 3

Social Interaction and the Minority-Majority Earnings Inequality: Why Being a Minority Hurts but Being a Big Minority Hurts More

Social interaction is an important vehicle of human capital acquisition and individuals prefer to interact with like people. In this chapter I establish that the positive role of social interaction in skill acquisition and sociocultural differences between minority and majority individuals that hinder their social interaction disadvantage the smaller social group, the minority, in terms of efficiency of human capital acquisition. The key insight of this chapter is that in a world where heterogeneous skills are available in skill-specific social networks these efficiency differentials systematically expose minority and majority individuals to different incentives as concerns their choice of skills. As a result, depending on the equilibrium organization of skill acquisition, minority and majority individuals acquire different (combinations of) skills. Such differentiation engenders the textbook substitution effect that drives an efficiency unit of minority labor to sell at a relatively lower wage in a region with higher percentage of minority people. The conditions under which the efficiency disadvantage of the minority in social interaction and the substitution effect explain the empirical findings that (i) minorities typically earn less than majorities and that (ii) the earnings gap is increasing in the relative size of a minority in a given region are established. In addition, this study offers an answer why some minorities earn more than majorities, why minority individuals tend to spend more time socializing in families than in schools, and why integration may harm minorities.

3.1. Introduction

Inequalities in socioeconomic conditions of Black and White Americans, Romany and White Europeans, and other minorities and majorities around the world are persistent and central features of the worldly history.[1] While there are many dimensions of socioeconomic inequality, labor income, as one of the major measures and determinants of socioeconomic inequality, is the principal focus of this study. Two robust empirical findings about the distribution of income between minority and majority peoples pose a challenge to economic theory. On the one hand, minorities typically earn less income per capita than majorities. On the other hand, minority-majority earnings disparity increases in the relative size of a minority in a region. The puzzling feature of these empirical regularities is that while being a member of the smaller social group in a region, the minority, is disadvantageous in earnings terms, minority people are relatively better off in regions where they are relatively less plentiful.

The existence of these empirical regularities, the scale puzzle, has been corroborated in a sizeable empirical literature.[2] The early empirical studies on this topic include Blalock (1956, 1957), Heer (1959), Brown and Fuguitt (1972), and Frisbie and Neidert (1977). For example, Heer (1959) finds a correlation of -0.71 between the ratio of Black and White median per capita incomes and the percentage of Blacks. Frisbie and Neidert estimate the correlations between minority-majority income disparity and minority share in the population between 0.19 and 0.70. They go as far as to conclude that "one of the most consistent findings … is that socioeconomic differentials vary directly with the relative numbers of a minority present in a given area …".[3] More recently, in a micro-econometric study about the earnings of Black, Hispanic, Asian, and White men in the US, Tienda and Lii (1987) establish the existence of significant minority-majority income differentials and confirm that minority labor market percentages favor the majority while disadvantaging the minorities themselves. Finally, focusing on migrants, Borjas

[1] As defined in Chapter 1, minority is understood to be a particular racial, ethnic, language, religious or national group of individuals who share socio-cultural characteristics such as culture, religion, language, history, beliefs, customs, values, and morals that make them distinct from the rest of the population – the majority. In a given region, the minority typically constitutes the smaller part of the population than the majority, but local concentrations may occur. The study does not deal with social groups formed on the basis of occupation, wealth, or other ordinal characteristics.

[2] Table 3A.1 in the Appendix summarizes the findings of the studies listed below in a greater detail.

[3] Frisbie and Neidert (1977), p. 1007

(1987) and Chiswick and Miller (2005) show that earnings of immigrants from a certain linguistic or ethnic group are decreasing in the concentration of similar people in the destination region. Based on these studies, the scale puzzle that (i) minority individuals on average earn less than majority individuals and that (ii) this earnings differential is increasing in minority share in population in a given region is taken as a stylized fact of minority-majority earnings inequality.[4]

From the theoretical perspective, the scale puzzle attracted considerable attention in sociological literature several decades ago. Williams (1947), Allport (1954), Blalock (1967), Reich (1971), and Bonacich (1972, 1976) explain the scale puzzle arguing that the hostility of a superordinate majority against minority people is increasing in the relative size of the minority. Another strand of literature, represented by Glenn (1964), Spilerman and Miller (1977), and Semyonov et al. (1984), advocates that it is the discriminatory occupational structure that creates an environment in which influx of minority workers crowds out majority workers into better jobs with higher pay which explains the scale puzzle.

Earnings inequality has always been a focal point of economics. Inspired by Becker (1957) and developed by Welch (1967) and Arrow (1972a, 1972b, 1973), minority-majority economic inequality is explored as a preference-driven phenomenon arising due to the so-called *taste for discrimination* of actors on the labor market. [5] Within this framework, the positive relationship between minority-majority earnings inequality and minority percentage can be explained as a consequence of increasing difficulty to avoid working for discriminating employers whenever minority percentage is high, for a given distribution of taste for discrimination among employers. In an approach that understands discrimination as a consequence of a specific form of asymmetric information in the labor market, *statistical discrimination*, Lundberg and Startz (2002) and Coate and Loury (1993), building on the groundbreaking ideas of Phelps (1972), Arrow (1972a, 1972b, 1973), and Aigner and Cain (1977), argue that a priori actual or perceived asymmetries are maintained in the equilibrium through self-fulfilling expectations. Moro and Norman (2004) show that in such context the welfare gain of majority individuals from

[4] Based on this empirical evidence, the proper interpretation of the scale puzzle involves comparing one minority across several regions of a given country, e.g. Blacks across U.S. counties, rather than different minorities in different countries, e.g. Chinese in Malaysia, Jews in the U.S., and Turks in Germany.

[5] See also Darity (1982, pp. 72-75), Arrow (1998), and Loury (1998).

discrimination increases in minority percentage, although the overall effect of minority percentage on its relative earnings in their study is nonmonotonic as discrimination equilibria are less likely if the minority is relatively large.

From what I denote the *local effects* perspective, researchers aim to explain quantitative differences in individual human capital and thus earnings across social groups as a consequence of local spillover effects involved in agents' social environment. Becker and Tomes (1979) and Loury (1981) argue that intergenerational transfers of ability to acquire human capital sustain human capital variation and thereby earnings inequality across families. Shifting the focus from the family to the neighborhood, Benabou (1993, 1996) and Durlauf (1994, 1996) explain persistent income stratification by the existence of local public goods or neighborhood externalities. In a similar vein, Steele (1992), Akerlof (1997), and Lundberg and Startz (1998) explicitly account for the role of social interaction in human capital distribution and suggest that it is the social or psychological (dynamic) externalities in segregated neighborhoods or workplaces that promote social and economic inequalities. In combination with the assumption of inferior initial conditions of minority people, as is often the case for immigrants or (past) discrimination, the local effects theories systematically explain persistent minority-majority earnings gap.

In this chapter, combining the local effects perspective with several insights about social interaction, I provide a novel theoretical explanation of the link between the relative size of minority population and its relative economic achievement, thereby explaining the scale puzzle. First, I establish that positive external effects in skill acquisition and sociocultural differences between a minority and a majority that hinder their social interaction in social networks[6] disadvantage the smaller social group, the minority, in terms of efficiency of human capital acquisition. As a consequence of this efficiency effect, a minority individual supplies less human capital and thus earns less than a majority individual, given the price of human capital. Second, the key insight of this chapter is that in a world where heterogeneous skills are available in skill-specific social networks these efficiency differentials systematically expose minority and

[6] As in the previous chapter, social network is understood to be a social structure between individual actors that facilitates social interaction among its members.

majority peoples to different incentives as concerns skill choice and, depending on the equilibrium organization of skill acquisition, make them acquire different (combinations of) skills. An important consequence of such differentiation, which has been corroborated by a number of studies,[7] is that wages per efficiency unit of minority and majority labor typically differ, since these are no longer perfect substitutes. The imperfect substitutability of minority and majority labor in turn engenders the substitution effect, which in the present context implies that an efficiency unit of minority labor sells at relatively lower wage in regions where the minority is relatively larger.[8] In effect, the efficiency and substitution effects work in opposite directions as concerns the relationship between minority share in the population and its relative earnings. The main result of this chapter is that there are equilibrium regimes of skill acquisition under which the efficiency and substitution effect explain the scale puzzle. I classify these equilibrium regimes and establish the parametric conditions that support this result.

The argument proceeds as follows. In the following section I describe the social and economic environment of the model and elaborate on the main assumptions on which the argument is based. Next, I present a formal model and establish its main predictions. Finally, I discuss the robustness and relevance of the presented theory and conclude.

3.2. The Social and Economic Environment

3.2.1. The Main Assumptions

This chapter draws on several insights about social embeddedness of human capital acquisition developed in the literature. That individuals learn from their peers, friends, and neighbors has been proposed by a number of scholars. [9] As Lucas (1988) points out, "human capital accumulation is a *social* activity, involving *groups* of people in a way that has no counterpart in

[7] To wit, indicating a degree of differentiation on the labor market, Altonji and Blank (1998) report that minority workers are overrepresented in less skilled jobs and Blacks in the US are overrepresented in some kinds of jobs such as public administration. Occupational differentiation explored by e.g. Blalock (1957), Brown and Fuguitt (1972), and Hirschman and Wong (1984). From the empirical perspective, Grant and Hamermesh (1981), Grossman (1982), Borjas (1983, 1987), and Kahanec (2005) establish imperfect substitutability of minority and majority labor.
[8] The substitution effect is a direct consequence of the textbook economic law of diminishing marginal product.
[9] Early theories about human capital include Becker (1962), Mincer (1958), and Schultz (1961). The literature on social embeddedness of human capital acquisition includes Rees and Schultz (1972), Loury (1977), Bourdieu (1986), and Coleman (1988, 1990).

the accumulation of physical capital."[10] Allen (1982), Ellison and Fudenberg (1993, 1995), and Bala and Goyal (1998) investigate the role of social interaction in learning about optimal actions. Valente (1995), Feick and Price (1987), Gladwell (2000), and Foster and Rosenzweig (1995) substantiate such approach and observe that social networks are an important vehicle of information sharing. These authors document that colleagues, friends, or neighbors share information about their discoveries, experiment outcomes, or search results. Conley and Udry (2002), Foster and Rosenzweig (1995), and Munshi (2002) provide evidence that social interactions significantly affect farmers' profitability upon adoption of new technologies, arguing that this finding implies that farmers learn about the best practices in social interaction with their peers and neighbors, rather than only mimicking their behavior.

A number of scholars, such as Glaeser et al. (2002), Foster and Rosenzweig (1995), and Lazear (1999), maintain that social interaction in social networks often involves positive externalities such that the aggregate resources of a network exceed the naïve sum of individual contributions. Foster and Rosenzweig (1995) develop a framework in which the efficiency of social learning improves in the number of involved individuals whenever social learning exhibits social memory.[11] Based on this literature, I adopt the premise that the benefits from social interaction are increasing in the number of people involved as the first essential assumption of this chapter.[12] Namely, I assume that skill acquisition process exhibits external network effects[13] that positively depend on the size of the social network in which the particular skill is acquired.

It is natural to argue that benefits from social interaction not only depend on the number of individuals one interacts with but also on who these individuals are. In the context of minority-majority social interaction, sociocultural differences between minorities and majorities are likely to determine the quality of social interaction in any network. To operationalize these sociocultural differences, in line with Poole (1927) and Lazear (1999), I define social distance to

[10] Italics are original, p.19.
[11] Goyal (2003) surveys the literature on social learning.
[12] Inefficiencies stemming from the size of social networks, such as inefficient herding, status, and congestion, are certainly possible. The focus of this chapter is on the benefits from social interaction in social learning, however.
[13] Network effects arise whenever benefits from a good or service, here the service of social network in skill acquisition process, increase in the number of individuals already owning that good or using that service. One consequence of a network effect is that the use of a network service by one individual indirectly benefits others who use it. This side effect in a transaction is known as network externality.

be the measure of subjective and objective dissimilarities between social groups that hinders social interaction between the members of these social groups.[14] The natural corollary of the definition of social distance above is that agent's ability to benefit from social interaction in a given network negatively depends on her social distance to the other members of this network. Based on this, the second essential assumption of this chapter is that individual benefits from network effects are decreasing in interpersonal social distance.[15]

To complete the description of the social organization of skill acquisition, given the omnipresent segregation of social institutions, it is assumed that institutionally exclusive and inclusive social networks exist in the economy.[16] Specifically, while inclusive social networks permit any membership, a given exclusive network only permits memberships from one social group.[17] The prime examples of typically exclusive networks include families, kinships, social networks in ghettoes, religious groups, expatriate communities, radical groups, and ethnically or religiously exclusive schools and clubs. Most schools, student societies, workplaces, academic communities, and cybernetworks[18] are typically inclusive. These examples suggest that exclusive and inclusive social networks are typically different with respect to, inter alia, their complexity, objectives, functions, and the strength of ethnic or religious character. Arguably, these differences transpire into the character of skills acquired in exclusive and inclusive networks.[19] Indeed, Coleman et al. (1966) and Heckman (2000) discuss these two kinds of skills and stress their importance for

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[14] In contrast to Akerlof (1997), who studies endogenous social distance between homogeneous agents, I consider social distance between members of different social groups to be a predetermined variable that reflects the defining distinctiveness of social groups.

[15] Note that social distance is fully symmetric on the individual level. Assuming a priori asymmetry of sociocultural differences, although trivially incorporable into the argument, would be largely ad hoc and racially prejudiced.

[16] There is an enormous literature on social structure and ethnic segregation. Recent contributions include Massey and Denton (1993) and Farley and Frey (1994). Ethnic segregation has been documented by e.g. Farley and Frey (1994), Glaeser and Vigdor (2001), Reardon et al. (2000).

[17] Thus, exclusive social networks are always segregated. Inclusive social networks may be integrated as well as segregated; the distinction made in this chapter is that exclusiveness (inclusiveness) is understood as exogenous institutional constraint on network membership while segregation (integration) as endogenous variable concerning equilibrium organization of social interaction.

[18] Social networks in the cyber space, such as the users of the Internet.

[19] Examples of skills acquired in exclusive networks include verbal and non-verbal communication skills including language skills, general social knowledge and socialization skills, capability of self-motivation, but also, whenever they are specific for the particular social group, particular arts and crafts skills. An example of minority specialization in a particular craft is the specialization of different Gypsy tribes in Romania in e.g. spoon-making (*Lingurari*), bear-leading, tinkering, and blacksmithing (*Ursari*), mining (*Rudari*), and goldsmithing (*Aurari*) (Fraser (1992)). Skills acquired in typically more formal inclusive social networks involve those in e.g. mathematics, medicine, metal processing, machine operating, and personnel management.

success in life. Based on these arguments, I assume that the skills acquired in exclusive networks are generally different from those acquired in inclusive networks. For the sake of brevity, I let “exclusive” and “inclusive” denote the respective social networks and skills.

3.2.2. The Driving Mechanisms: The Efficiency and Substitution Effects

Having described the key assumptions, in this section I indicate the main mechanisms of the formal argument. First, through network effects, the efficiency of skill acquisition in a given social network is a function of its size. In any given network, due to the social distance between minority and majority, individuals benefit from a larger relative number of network members from their own social group. Moreover, if individuals from some social group choose to segregate, the size of their segregated social networks is limited by the size of their social group. Therefore, the efficiency effect favors relatively larger social groups and so offers an explanation of the first part of the scale puzzle: why minorities typically earn less than majorities.

Second, for a member of a given social group network effects and social distances generate efficiency benefits to joining and investing in that social network that is chosen by the other members of his or her social group. These efficiency benefits induce minority and majority each to specialize in one, possibly different social network or, if exclusive and inclusive skills are both essential for an individual an their compositions are different, to invest their time differently between exclusive and inclusive social networks. As a result, network effects and social distances direct minority and majority individuals to acquire different skills or they induce them to acquire different combinations of skills. Such differentiation engenders the substitution effect: individuals who supply skills that are scarcer earn higher wage for an efficiency unit of their labor than those that supply more abundant skills. It follows that the substitution effect rewards members of smaller social groups, as the aggregate supply of their skills is relatively smaller. [20] Consequently, the substitution effect offers an explanation of the second part of the scale puzzle: that smaller minorities earn relatively more than larger ones.

[20] Besides the obvious reason that a smaller social group supplies lesser measure of skills on aggregate, due to the efficiency it also has a lower per capita supply of skills.

To summarize, as the relative size of a social group increases, it benefits from the efficiency effect while being hurt by the substitution effect in relative earnings terms and vice versa. In the analysis below I formally demonstrate that these two effects can produce a nonmonotonic pattern of inequality between social groups that is consistent with the scale puzzle. The conditions under which this is the case are then established and discussed.

3.3. The Model

3.3.1. Labor Demand

In this section, I study the demand side of the labor market where the society is divided into two social groups – the minority *I* and the majority *J* – and clarify the extent to which it accounts for the substitution and efficiency effects. Let *i* and *j* denote the respective members and *I* and *J* the respective measures of the continuums of minority and majority agents, where $I < J$ and I adopt a convenient normalization that $I + J = 1$. I assume that all individuals are identical with respect to their preferences and endowments, group membership excepting. Individual preferences are represented by a standard utility function $u(\cdot)$ that increases in individual consumption, C_k, where $k \in \{i, j\}$.

Let the consumption good be produced by combining labor input of minority individuals, H_i, and majority individuals, H_j, in a perfectly competitive industry according to the constant elasticity of substitution (CES) aggregate production function

$$C = \left(\left(\int_0^I H_i di\right)^{(\rho-1)/\rho} + \left(\int_0^J H_j dj\right)^{(\rho-1)/\rho}\right)^{\rho/(\rho-1)} \tag{3.1}$$

with the elasticity of substitution $\rho > 1$. According to this specification, labor of any given type has decreasing marginal returns, production exhibits constant returns to scale, and no type of labor is essential in production. Moreover, while members of the same social group are perfectly substitutable in production, the elasticity of substitution between minority and majority labor ρ is not a priori restricted to be finite. In particular, whenever minority and majority labor is perfectly substitutable, production does not distinguish between minority and majority labor.[21] Similarly to the statistical discrimination literature, I adopt the asymmetric information hypothesis about the labor market. In particular, I assume that while employers observe the aforementioned observable characteristics of social group membership of individuals[22] and the measures of labor they supply, H_i and H_j, they are not able to directly observe the marginal product of labor supplied by any individual.[23] From experience or statistical investigation, however, they understand that social group membership predicts the marginal product of individual labor and thus they know the expected marginal products of members of any social group. By corollary, employees from the same social group are not distinguishable with respect to their type of labor, as they do not perceptibly differ, and they always receive the same wage for a unit of their labor input.

Given the infinitesimal measure of any individual, all prices are taken as given at the individual level and the production function (3.1) gives rise to individual demands for labor

$$H_i = P_C^{\rho} W_i^{-\rho} C / I \tag{3.2a}$$

$$H_j = P_C^{\rho} W_j^{-\rho} C / J , \tag{3.2b}$$

where P_C is the price of consumption good C and W_i and W_j are the wages per unit of labor input of minority and majority individuals, respectively. As a result of the homogeneity of degree one of the CES production function, the sector does not generate any profits in the equilibrium and we can derive that $P_C = \left(W_i^{1-\rho} + W_j^{1-\rho}\right)^{1/(1-\rho)}$. Combining the demands for H_i and H_j in (3.2a-b), one obtains the relative demand for labor

$$w = \left(\frac{I}{1-I} h\right)^{\frac{-1}{\rho}} , \tag{3.3}$$

where $w \equiv W_i / W_j$ and $h \equiv H_i / H_j$. Equation (3.3) is the main result from studying the demand side of the economy. It plainly reveals the substitution effect that, given a finite ρ, the relative

[21] The issue of substitutability of minority and majority labor is elaborated in the analysis of the supply side below. Proposition 3 implies that the production function (3.1) can be seen as a harmless simplification of a more general production technology with an arbitrary number of types of labor with a given elasticity of substitution.
[22] E.g. skin color, group-specific name, or accent.
[23] This assumption also implies that employers cannot remunerate a worker separately for the skills and labor time he or she supplies.

wage w is decreasing in the relative size of the social group I and its relative supply of labor h. It also highlights the importance of ρ for the substitution effect: only a finite ρ makes the substitution effect operative.

Let us now turn to earnings as determined by the demand side. Premultiplying equation (3.3) by h and defining $\Omega_k \equiv H_k W_k$ to be the labor earnings (and the only income) of individual k, we derive the following expression for minority-majority ratio of per capita earnings:

$$\omega \equiv hw = h\left(\frac{I}{1-I}h\right)^{\frac{-1}{\rho}} = \left(\frac{I}{1-I}\right)^{\frac{-1}{\rho}} h^{\frac{\rho-1}{\rho}}. \tag{3.4}$$

Observing the properties of equation (3.4), at least two conditions about the relative supply of labor under which equation (3.4) generates patterns of income inequality consistent with the scale puzzle for some I, involving regularities that $\partial\omega(I)/\partial I < 0$ and $\omega(I) < 1$, can be identified. First, since $(I/(1-I))^{\frac{-1}{\rho}} > 1$, the efficiency effect must favor members of larger social groups so that $h(I) < 1$ for some I and thus there exists ρ such that $\omega(I) < 1$ for some I. [24] Below, I will show how the model satisfies this condition when taking into account the organization of supply of labor and skill acquisition that is characterized by network effects and social distances, as described above.

The second condition constitutes the core of the argument. Equation (3.4) clearly reveals that whenever minority and majority labor is perfectly substitutable and thus $\rho \to \infty$, equation (3.4) boils down to $\omega = h$ and the substitution effect is non-operative, since wages per efficiency unit of labor are equal for all individuals. In such case, as established below, network effects and social distances still generate minority-majority earnings gap but the gap is diminishing in the relative size of minority, contrary to the scale puzzle. Therefore, an additional formal argument has to be made in order to substantiate the existence of the substitution effect. In particular, it is essential to establish that minority and majority labor is imperfectly substitutable; that is, that ρ is finite. In the following section I analyze the supply of labor and show how the supplies of

[24] That such ρ exists is clear from the fact that $\rho \to \infty$ implies $\omega \to h$. Thus, if h<1 there always exists large enough ρ such that $\omega < 1$.

minority and majority labor depend on the sizes of social groups through network effects and social distances. Most importantly, I establish that, under certain conditions, network effects and social distances determine the organization of supply of labor such that it justifies imperfect substitutability of minority and majority labor and thus the existence of the substitution effect.

3.3.2. Labor Supply

Individuals are each endowed with one unit of time that they divide between acquisition of human capital and time spent working. Human capital as well as time spent working increase the individual supply of efficient labor H_k, which I conceptualize to be the measure of labor in efficiency units that comprises labor time and human capital. In particular, it is assumed that efficient labor is a composite of time-empowered exclusive and inclusive skills. Denoting exclusive and inclusive skills and network types $m \in \{x, n\}$, respectively, I assume the constant elasticity of substitution technology of producing H_k efficiency units of labor

$$H_k = \left[\left(S_{k,x}\left(T_{k,x} - L_{k,x}\right)\right)^{(\varepsilon-1)/\varepsilon} + \left(S_{k,n}\left(T_{k,n} - L_{k,n}\right)\right)^{(\varepsilon-1)/\varepsilon}\right]^{\varepsilon/(\varepsilon-1)} \tag{3.5}$$

where $S_{k,m}$ is the measure of skills of type m of agent k, $T_{k,m}$ is the corresponding total time invested in acquiring skills and utilizing them in production, and $L_{k,m}$ is the corresponding time spent on acquiring skills.[25] Accordingly, $T_{k,m} - L_{k,m}$ is the time individual k allocates to utilizing skill m in production. The finite and positive parameter ε denotes the elasticity of substitution between time-empowered exclusive and inclusive skills in production of individual efficient labor and reflects their imperfect substitutability. Skills are acquired according to a decreasing-returns-to-scale technology in social networks

$$S_{k,m} = L_{k,m}^{\phi}\left(1 + N_{k,m}\right), \tag{3.6}$$

where $N_{k,m}$ is the external network effect benefit in network m enjoyed by its member k and $\phi \in (0,1]$ is the measure of decreasing returns to time spent in skill acquisition. Throughout the chapter I assume that agents take network effects as given, given the infinitesimal measure of any individual.

[25] This technology of producing efficient labor H_k can be, without any bearing on the argument of this chapter, reinterpreted as the production function of the intermediate good H_k, which is an input in the production of the consumption good C.

As discussed above, exclusive and inclusive social networks differ in terms of membership they permit and skills they support. Given the difference of exclusive and inclusive skills, from the production technology (3.5) we see that the qualitative properties of individual labor are determined by the combination of skills that constitute efficient labor of a worker. I operationalize this qualitative variation of efficient labor such that efficiency units of labor that consist of different (combinations of) skills are imperfect substitutes on the labor market. Thus, for example, if the skills of one individual are predominantly exclusive and the skills of the other agent are predominantly inclusive, the elasticity of substitution of labor of these two individuals is finite. Formally, defining $s_k \equiv S_{k,x} / S_{k,n}$, whenever $s_k \neq s_{k'}$ ($s_k = s_{k'}$) for individuals k and k', the elasticity of substitution between H_k and $H_{k'}$ is finite (infinite). Because s_k is determined by the organization of human capital acquisition, which is endogenous in the model, the elasticity of substitution between minority and majority labor ρ is in this sense endogenous as well.

Turning to the individual problem of time allocation, individuals maximize their utility, taking their resource constraints, available technologies, network effects, wages per unit of their efficient labor[26], and the price level as given. From the properties of the utility function it follows that the agents' problem boils down to

$$H_k^* \equiv \underset{L_{k,m},T_{k,m}}{Max} \left|H_k\right| \tag{3.7}$$

subject to (3.5), (3.6), and the resource constraints $T_{k,m} \geq 0$, $L_{k,m} \geq 0$, and $T_{k,x} + T_{k,n} \leq 1$. Solving the maximization problem, it is straightforward to see that individuals divide their time between acquisition and utilization of skills according to the rule[27]

$$L_{k,m} = \frac{\phi}{1+\phi} T_{k,m}\,. \tag{3.8}$$

Thus, agent k spends a fixed share $\phi/(1+\phi)$ of the time that he allocates to skill m, $T_{k,m}$, on acquiring this skill. The rest of this time, $T_{k,m}/(1+\phi)$, or $T_{k,m} - L_{k,m}$, is spent on utilizing it. The

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[26] As a consequence of the assumption of asymmetric information in the labor market discussed above.
[27] Proof in the Appendix.

following proposition characterizes the solution of the maximization problem (3.7). To save on notation in what follows I define $\widetilde{N}_{k,m} \equiv \left((\phi/(1+\phi))^{\phi} (1-\phi/(1+\phi))(1+N_{k,m}) \right)^{(\varepsilon-1)/\varepsilon}$.

Proposition 1

If $\varepsilon \geq (\phi+1)/\phi$, the optimal solution to agents' problem (3.7) arises as a corner solution where all the time available to an individual is spent on acquisition and utilization of the one skill whose acquisition is most efficient. In particular,

$$\left(\varepsilon \geq (\phi+1)/\phi \wedge \widetilde{N}_{k,n} \geq \widetilde{N}_{k,x} \right) \Rightarrow H_k^* = \widetilde{N}_{k,n}^{\varepsilon/(\varepsilon-1)} \tag{3.9a}$$

and

$$\left(\varepsilon \geq (\phi+1)/\phi \wedge \widetilde{N}_{k,n} \leq \widetilde{N}_{k,x} \right) \Rightarrow H_k^* = \widetilde{N}_{k,x}^{\varepsilon/(\varepsilon-1)}. \tag{3.9b}$$

If $\varepsilon < (\phi+1)/\phi$, the interior solution $H_k^* = \left(\widetilde{N}_{k,x} T_{k,x}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}} + \widetilde{N}_{k,n} T_{k,n}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}} \right)^{\varepsilon/(\varepsilon-1)}$ (3.10)

Solves the agents' problem (3.7), where the optimal time allocation is governed by the arbitrage condition

$$t_k \equiv \frac{T_{k,x}}{T_{k,n}} = \left(\frac{1+N_{k,x}}{1+N_{k,n}} \right)^{\frac{\varepsilon-1}{1+\phi-\varepsilon\phi}}, \tag{3.11}$$

giving rise to equilibrium time allocations $T_{k,x} = t_k/(1+t_k)$ and $T_{k,n} = 1/(1+t_k)$.

Proof in the Appendix.

Corresponding to interior and corner solutions in Proposition 1, I define two classes of regimes, specialization and diversification, respectively. In particular, specialization regimes prevail if and only if $\varepsilon \geq (\phi+1)/\phi$ and diversification regimes prevail if and only if $\varepsilon < (\phi+1)/\phi$.[28] From Proposition 1 and equations (3.5), (3.6), and (3.8), under specialization the relative supply of labor is

[28] In general, there may be dual regimes in which agents of one social group diversify while agents of the other social group specialize. Because the choice to diversify or specialize entirely depends on parameters ε and ϕ of the model and these are assumed to be the same for every agent in the economy, I disregard these cases here. The rationale for this approach is that the emphasis in this chapter is put on the question how network effects engender heterogeneity of human capitals of minority and majority and how this heterogeneity translates into income inequality when individual characteristics are the same for both social groups.

$$h = \frac{1+N_{i,m}}{1+N_{j,m}} \tag{3.12}$$

and, under diversification,

$$h = \frac{\left(1/(1+t_i)\right)^{\phi+1}\left(\left(t_i^{\phi+1}(1+N_{i,x})\right)^{(\varepsilon-1)/\varepsilon}+(1+N_{i,n})^{(\varepsilon-1)/\varepsilon}\right)^{\varepsilon/(\varepsilon-1)}}{\left(1/(1+t_j)\right)^{\phi+1}\left(\left(t_j^{\phi+1}(1+N_{j,x})\right)^{(\varepsilon-1)/\varepsilon}+(1+N_{j,n})^{(\varepsilon-1)/\varepsilon}\right)^{\varepsilon/(\varepsilon-1)}}. \tag{3.13}$$

As one can see, the relative supply of labor is fully determined by network effects and time allocation in skill acquisition.[29] In the following section I specify network effects and investigate the allocation of individual involvements across networks under the various equilibrium regimes of skill acquisition.

3.3.3. Network Effects

In the skill acquisition technology (3.6), external network effects play a pivotal role in determining the efficiency of acquiring skills in a social network and thus the equilibrium allocation of individual involvements across social networks. In line with the arguments above, network effects that any given agent *k* enjoys in social network *m* depend on the extent of social interaction therein, which is measured by the total time agents spend interacting in this network. Consistently with the assumption about social distance, agents benefit more from interaction with ethnically similar agents as compared to ethnically distant agents. This effect is captured by the social distance parameter $\delta > 0$. For the sake of clarity of exposition, I posit that the one-dimensional social distance parameter completely represents the multidimensional dissimilarities between the minority and the majority. Based on these premises, I assume network effect specifications

$$N_{i,m}(I_m, L_{i,m}, J_m, L_{j,m}, \delta) = \left(I_m L_{i,m} + \frac{1}{1+\delta} J_m L_{j,m}\right)^{\gamma} \tag{3.14}$$

$$N_{j,m}(I_m, L_{i,m}, J_m, L_{j,m}, \delta) = \left(\frac{1}{1+\delta} I_m L_{i,m} + J_m L_{j,m}\right)^{\gamma}, \tag{3.15}$$

where the parameter $\gamma \in (0,1]$ captures decreasing returns to involvement of individuals in a given social network and I_m and J_m are the numbers of, respectively, minority and majority

[29] In particular, it does not depend on wages. The reason is that individuals take wages as given, time has no other value but in skill acquisition, and skill acquisition does not involve any pecuniary exchange.

members in network m. These numbers depend on the equilibrium organization of skill acquisition as discussed below.

3.3.4. Equilibria

I adopt the Nash concept of equilibrium where agents choose social networks (skills) freely and the equilibrium arises as the state where no agent has incentives to deviate, that is, to change his or her allocation of time across networks. Given this equilibrium concept, we can state the following general propositions about stable equilibrium regimes of skill acquisition:

Proposition 2
In any stable equilibrium, no agent is involved in more than one network of any given type, exclusive or inclusive.
Proof in the Appendix.

Proposition 3
In any stable equilibrium, all members of a given social group choose the same combination of skills to acquire.
Proof in the Appendix.

Proposition 2 is a consequence of network effects: in a stable equilibrium, there cannot be two (or more) equally efficient social networks of the same type for any given individual because any perturbation of agents' involvements makes one of them less efficient and causes this individual to abandon it. Proposition 3 is mainly due to asymmetric information in the labor market that implies that individuals take their wages as given with respect to their choice of skills, so this choice is purely driven by efficiency concerns. Similarly as in Proposition 2, no stable equilibrium involves two distinct equally efficient combinations of social networks. Consequently, given asymmetric information in the labor market, network effects and social distances in skill acquisition coordinate individuals such that at most two different types of labor are supplied – minority- and majority-specific. In this sense, as mentioned above, the production function (3.1) can be seen as a harmless simplification of a more general production technology with an arbitrary number of types of labor H_k.

3.3.4.1. Specialization

This section studies equilibrium regimes of skill acquisition under specialization. Given Proposition 2 and 3, under specialization all members of a given social group choose exactly one and the same social network to join and thus skill to acquire. In effect, five different non-empty networks may arise in the economy under specialization; these are highlighted in Table 3.1.[30]

Table 3.1: Social networks under specialization.

<table>
<tr><th>Social network type</th><th>Permitted membership</th><th>Possible membership</th></tr>
<tr><td rowspan="2">Minority exclusive</td><td rowspan="2">Minority</td><td>I</td></tr>
<tr><td>Empty</td></tr>
<tr><td rowspan="2">Majority exclusive</td><td rowspan="2">Majority</td><td>J</td></tr>
<tr><td>Empty</td></tr>
<tr><td rowspan="4">Inclusive</td><td rowspan="4">Any</td><td>I</td></tr>
<tr><td>J</td></tr>
<tr><td>I and J</td></tr>
<tr><td>Empty</td></tr>
</table>

It turns out that there are three stable and two conditionally stable equilibrium allocations of minority and majority individuals across social networks and thus skills of different types under specialization. I list these equilibrium allocations and investigate their stability in Proposition 4. Table 3.2 depicts the properties of these equilibria.

Proposition 4
Under specialization the following equilibria are always stable in the Nash sense:

1. Each social group specializes in exclusive skills joining its exclusive network (EE)
2. Social groups specialize in inclusive skills joining the same inclusive network (II)
3. The minority specializes in inclusive and the majority in exclusive skills (IE)

The following allocations

[30] It is worthwhile to recall that whether a network is exclusive or inclusive is an institutional constraint and is not determined by who its members are. For example, it may happen that a school as a social network permits minority (and majority) people to participate, but these choose not to. The school then only has majority pupils, but it remains inclusive, nonetheless.

4. The minority specializes in exclusive and the majority in inclusive skills (EI)
5. Social groups specialize in inclusive skills, acquiring them in two non-connected inclusive networks, each composed of members of only one social group (IS)

are stable if and only if

$$I \geq 1/(2+\delta). \tag{3.16}$$

Proof in the Appendix.

Table 3.2: Specialization equilibria.

Equilibrium	Segregation vs. Integration	Elasticity of substitution	Network membership			
			Exclusive		Inclusive	
			Minority I_x	Majority J_x	Minority I_n	Majority J_n
EE	Segregation	Infinite	I	J	0	0
II	Integration	Infinite	0	0	I	J
IE	Segregation	Finite	0	J	I	0
EI	Segregation	Finite	I	0	0	J
IS	Segregation	Infinite	0	0	I	J

The most important insight of Proposition 4 is that there are stable equilibria, EI and IE, in which minority and majority people choose different types of skills.[31] These equilibria substantiate imperfect substitutability of minority and majority labor, that is, a finite ρ, and thus the existence of the substitution effect.

To understand stability of specialization equilibria, one needs to recall that, due to asymmetric information, employers differentiate wages per unit of efficient labor across social groups but not within groups and that individuals cannot change their group membership. Therefore, individuals pick those networks to acquire skills that they are allowed to join and that offer the largest benefits from network effect (and thus are the most efficient for skill acquisition). In particular,

[31] Namely, $s_i^{EI} \to \infty$, $s_j^{EI} = 0$, $s_i^{IE} = 0$, and $s_j^{IE} \to \infty$. Therefore $s_i^{EI} \neq s_j^{EI}$ and $s_i^{IE} \neq s_j^{IE}$, which implies that ρ^{EI} and ρ^{EI} are finite. Clearly, $s_i^{EE} = s_j^{EE}$, $s_i^{II} = s_j^{II}$, and $s_i^{IS} = s_j^{IS}$ and thus $\rho^{EE} = \rho^{II} = \rho^{IS} \to \infty$.

this implies that deviation to an empty social network[32] is never beneficial and for any individual it is preferable to be a member of the social network consisting of the other members of her social group.[33] This implies that the only possibly gainful and allowed deviation for an individual is that of switching to a non-empty inclusive social network of people from the other social group. In the IE equilibrium the only such possibility is a deviation of a majority individual to the inclusive network consisting of minority individuals. Such deviation would involve comparing the network benefits in the original social network, $N_{j,x}^{IE} = J^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}$, to the network benefits obtained upon deviation, $N_{j,n}^{IE} = \left(1/(1+\delta)I\right)^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}$. For this marginal deviation not to occur, the stability condition is $N_{j,x}^{IE} \geq N_{j,n}^{IE}$, which yields $J \geq I/(1+\delta)$. This condition is always satisfied. Consequently, the IE equilibrium is always stable. Similar arguments hold for the other specialization equilibria. The intuition behind the condition (3.16) is that in EI and IS equilibria minority individuals prefer segregated social interaction if and only if benefits from integration are low due to a relatively large size of the minority *I* or a large social distance δ.

Relative Income under Specialization

In this section I turn to the particular pattern of earnings inequality as predicted by the model under specialization equilibria. Plugging the results from equations (3.12), (3.8), and (3.4), specifying the network effects according to (3.14) and (3.15), and taking the network sizes from Table 3.2, the following result for relative earnings ensues:

$$\omega^{r}(I) = \left(\frac{I}{1-I}\right)^{\frac{-1}{\rho}} \left(\frac{1 + I^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}}{1 + (1-I)^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}}\right)^{\frac{\rho-1}{\rho}}, \tag{3.17}$$

where the superscript *r* denotes the particular equilibrium; in equation (3.17) $r \in \{IE, EI\}$. Given this result, let us state one of the key propositions of this chapter.

Proposition 5

Under the IE equilibrium for any $\rho > \rho' \equiv \left(\left(2(\phi+1)/\phi\right)^{\gamma} + \gamma + 1\right)\gamma^{-1}$ there always exists a

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[32] Deviating to an empty network involves setting it up. The implicit assumption of zero set-up costs of any network by any individual is a harmless simplification.

[33] See also Proposition 3 and its proof.

range of relative minority size *I* such that the pattern of earnings inequality is consistent with the scale puzzle. There always exists sufficiently large social distance δ such that the same is true for the EI equilibrium. In particular, in such range $\partial\omega^r(I)/\partial I < 0$ and $\omega^r(I) < 1$, where $r \in \{EI, IE\}$.

Proof in the Appendix.

Thus, under the EI and IE equilibria, where minority and majority individuals acquire different skills and thus ρ is finite, the model predicts earnings inequality that is consistent with the scale puzzle for some range of *I* and large enough ρ. Intuitively, because ρ is finite in the EI and IE equilibria and hence the substitution effect is operative, there exists sufficiently small *I* for which minority labor is scarce enough to make minority earn more than majority.[34] On the other hand, a large enough ρ ensures that the substitution effect does not completely override the efficiency effect and there exist some *I* for which minority earns less than majority. For such finite and sufficiently large ρ, given the continuity of $\omega(I)$, there must be a downward sloping segment of $\omega(I)$ that is below one for some range of *I*. Such segment is congruent with the scale puzzle.

One can easily verify that under all specialization equilibria the efficiency effect favors relatively larger social groups and in particular that the relative supply of labor of minority individuals is increasing in their share in population, that is, $\partial h(I)/\partial I > 0$. To wit, under the EI, IE, EE, and IS equilibria we obtain that $h(I) = \dfrac{1 + I^\gamma (\phi/(1+\phi))^\gamma}{1 + (1-I)^\gamma (\phi/(1+\phi))^\gamma}$, which is increasing in *I*, as follows from the fact that the nominator is increasing in *I* and the denominator is decreasing in *I*. Similar result holds for the II equilibrium, where $h(I) = \dfrac{1 + \left(I^\gamma + (1-I)^\gamma/(1+\delta)\right)(\phi/(1+\phi))^\gamma}{1 + \left(I^\gamma/(1+\delta) + (1-I)^\gamma\right)(\phi/(1+\phi))^\gamma}$. Given that $\partial h(I)/\partial I > 0$, the specialization equilibria EE, II, and IS predict that relatively larger minorities earn relatively more than smaller ones, formally, $\partial\omega^r(I)/\partial I > 0$ for $r \in \{EE, II, IS\}$. To validate this claim, knowing that $\partial h(I)/\partial I > 0$, one only needs to realize that ρ is infinity under these equilibria and thus $\omega^r(I) = h^r(I)$ for $r \in \{EE, II, IS\}$.

[34] Social distance δ has to be large enough to make such case under the EI equilibrium stable.

3.3.4.2. Diversification

In the following sections I investigate whether the scale puzzle can be theoretically explained if the elasticity of substitution between skills ε is relatively small such that diversification arises. As argued above, diversification equilibria arise in the equilibrium if and only if the two types of skills are complements or poor substitutes or there is sufficient degree of decreasing returns in skill acquisition such that $\varepsilon < (\phi + 1)/\phi$. Recalling that in diversification equilibria all agents acquire both exclusive and inclusive skills, besides the optimality condition in equation (3.8), the arbitrage condition in equation (3.11) is binding as well. Because all agents of a given type choose the same set of networks and thus skills to acquire, as we know from Proposition 3, two different equilibria can arise. In the DI equilibrium social groups acquire exclusive skills in their group-specific social network and inclusive skills in one integrated inclusive social network where both social groups interact. In the DS equilibrium, on the other hand, the inclusive skills are acquired in two segregated minority- and majority- only inclusive social networks. In this sense the DI equilibrium is integrated and the DS equilibrium segregated.[35] The following proposition discusses the stability of these equilibria; the intuition behind the condition (3.16) is the same as in Proposition 4 and concerns segregation of inclusive networks.

Proposition 6
The DI equilibrium of diversification is always stable. The DS equilibrium of diversification is stable if and only if the condition (3.16) holds.
Proof in the Appendix.

In the DI equilibrium, from Proposition 2 we know that $T_{k,x}^{DI} = t_k^{DI}/\left(1 + t_k^{DI}\right)$ and $T_{k,n}^{DI} = 1/\left(1 + t_k^{DI}\right)$. For expositional convenience, I adopt here the network effects specifications $N_{i,m}(I_m, J_m, \delta) = \left(I_m + J_m/(1+\delta)\right)^{\gamma}$ and $N_{j,m}(I_m, J_m, \delta) = \left(I_m/(1+\delta) + J_m\right)^{\gamma}$, assuming that network effects depend on the number of network members only. This network effect specification and the fact that all agents join all permissible networks under diversification such

[35] Note, however, that there is a degree of segregation in the DI equilibrium as well, as the exclusive networks are by definition segregated.

that $N_{i,x}^{DI} = I^{\gamma}$, $N_{i,n}^{DI} = \left(I + (1-I)/(1+\delta)\right)^{\gamma}$, $N_{j,x}^{DI} = (1-I)^{\gamma}$, and $N_{j,n}^{DI} = \left(I/(1+\delta) + (1-I)\right)^{\gamma}$ result in the following specifications of relative times spent in any social networks:

$$t_i^{DI} = \left(\frac{1 + I^{\gamma}}{1 + \left(I + (1-I)/(1+\delta)\right)^{\gamma}} \right)^{\frac{\varepsilon-1}{1+\phi-\varepsilon\phi}} \tag{3.18a}$$

and

$$t_j^{DI} = \left(\frac{1 + (1-I)^{\gamma}}{1 + \left(I/(1+\delta) + (1-I)\right)^{\gamma}} \right)^{\frac{\varepsilon-1}{1+\phi-\varepsilon\phi}} . \tag{3.18b}$$

Recalling that $I < J$, $\delta > 0$, and $\varepsilon < (\phi+1)/\phi$ under the DI equilibrium, it is straightforward to observe that the ratios in the parenthesis in equations (3.18a-b) are less than one. For this reason, the results in equations (18a-b) reveal that all people spend more time in exclusive networks than in inclusive ones whenever $\varepsilon < 1$. This result arises as the consequence of skill complementarity that forces individuals to compensate for their lower efficiency in exclusive networks by the longer times spent in exclusive networks. Similarly, if $\varepsilon > 1$ and the DI equilibrium arises, all agents spend more time in inclusive networks. Noting from equation (3.8) that $t_k = l_k$ where $l_k \equiv L_{k,x} / L_{k,n}$, these results also hold for times spent on skill acquisition. Finally, if the technology of combining skills is Cobb-Douglas and $\varepsilon = 1$, individuals spend equal shares of their time in exclusive and inclusive networks.

Having computed the equilibrium time allocations for each social group, in this section I investigate differences in time allocations between social groups as they are closely related to the key question about substitutability of minority and majority labor. Proposition 7 states the first result in this respect:

Proposition 7

Under the DI equilibrium, minority individuals spend relatively more time in exclusive networks than majority individuals whenever $\varepsilon < 1$ such that complementarity of exclusive and inclusive skills prevails. Formally, $\varepsilon \gtreqless 1$ implies $t_i^{DI} / t_j^{DI} = l_i^{DI} / l_j^{DI} \lesseqgtr 1$.

Proof in the Appendix.

These results stem from the relatively smaller efficiency of the exclusive networks of the minority as compared to those of the majority. As a result, if there is complementarity of skills such that $\varepsilon < 1$, as compared to the majority, minority individuals spend more time in their exclusive networks in order to compensate for this handicap. This finding reveals that the often-observed lesser involvement of minorities in formal educational institutions, as compared to the majority population, may be explained by inferior efficiency of social interaction in minority exclusive networks. The opposite result holds whenever skills are substitutes such that $\varepsilon < 1$ and diversification prevails. The same intuition governs the next proposition that states a much more important insight; namely, that minority and majority individuals choose different combinations of skills in the DI equilibrium.

Proposition 8

Social groups of different sizes choose different skill compositions in the DI equilibrium, in particular, $s_i^{DI} < s_j^{DI}$.

Proof in the Appendix.

Consequently, even though minority agents under some circumstances spend more time in their exclusive networks in the DI equilibrium, they unambiguously acquire relatively *less* exclusive skills than majority individuals. The key result here is that skill composition is different across social groups under the DI equilibrium of diversification and, therefore, the elasticity of substitution between labor of minority and majority individuals is finite.

Let us now turn to the DS diversification equilibrium under which minority and majority individuals join two disconnected inclusive networks as well as their exclusive networks. Under this equilibrium inclusive and exclusive networks provide the same network effect benefits for their members, as they are of the same size and composition. It follows that people distribute their time evenly between exclusive and inclusive networks and, as a consequence, have the same shares of exclusive and inclusive skills in the labor they supply. Therefore, their labor is perfectly substitutable on the labor market and they earn the same wage per efficiency unit of their labor.

Relative Earnings under Diversification

In this section I investigate relative earnings under the two diversification equilibria. Plugging the relative supply of labor (3.13) into (3.4), the relative income under the DI equilibrium is

$$\omega^{DI}(I)=\left(\frac{I}{1-I}\right)^{\frac{-1}{\rho}}\left(\frac{\left(\frac{1}{1+t_i^{DI}}\right)^{\phi+1}\left(\left(\left(t_i^{DI}\right)^{\phi+1}\left(1+N_{i,x}^{DI}\right)\right)^{(\varepsilon-1)/\varepsilon}+\left(1+N_{i,n}^{DI}\right)^{(\varepsilon-1)/\varepsilon}\right)^{\varepsilon/(\varepsilon-1)}}{\left(\frac{1}{1+t_j^{DI}}\right)^{\phi+1}\left(\left(\left(t_j^{DI}\right)^{\phi+1}\left(1+N_{j,x}^{DI}\right)\right)^{(\varepsilon-1)/\varepsilon}+\left(1+N_{j,n}^{DI}\right)^{(\varepsilon-1)/\varepsilon}\right)^{\varepsilon/(\varepsilon-1)}}\right)^{\frac{\rho-1}{\rho}} \tag{3.19}$$

where the respective $N_{k,m}^{DI}$ and t_k^{DI} are specified above.

Proposition 9

Under the DI diversification equilibrium of human capital acquisition there always exists ρ'' such that for any $\rho > \rho''$ there always exists a range of relative minority size *I* such that the pattern of earnings inequality is consistent with the scale puzzle. In particular, in this range $\partial\omega^{DI}(I)/\partial I < 0$ and $\omega^{DI}(I) < 1$.

Proof in the Appendix.

Proposition 9 shows that under the DI diversification equilibrium, in which minority and majority individuals acquire different skills and thus ρ is finite, the model predicts earnings inequality that is consistent with the scale puzzle for some range of *I* and large enough ρ. The intuition is similar to that of Proposition 5 for the specialization equilibria EI and IE. Similarly as in the EI and IE equilibria, small enough minorities outperform majorities in terms of earnings.

Under the DS equilibrium, however, minority and majority individuals, facing identical efficiencies in completely segregated social networks, spend equal times in each type of networks and acquire the same composition of skills, $s_i^{DS} = s_j^{DS} = 1$. Therefore, the elasticity of substitution of their labor ρ is infinite. Using this result and the facts that individuals divide their time evenly between acquisition and utilization of skills and that network effects are I^{γ} for minority individuals and $(1-I)^{\gamma}$ for majority individuals in any network they join, we obtain that

$$\omega^{DS}(I) = \frac{1 + I^{\gamma}}{1 + (1 - I)^{\gamma}}. \tag{3.20}$$

Clearly, $\omega^{DS}(I) = \dfrac{1 + I^{\gamma}}{1 + (1 - I)^{\gamma}} < 1$, or, in plain words, under the DS equilibrium minority individuals are always poorer than majority individuals. As it is easy to see, in conflict with the scale puzzle, equation (3.20) predicts that minority-majority earnings gap is decreasing in minority relative size.

3.4. Discussion

3.4.1. The Roles of Integration and Exclusion

In the presented model integration has a distinct role in determining relative income of minorities that challenges the habitual belief that integration leads to greater equality between social groups. While it is true that both minority and majority individuals benefit from integration through the increased network effects that integration brings about, integration disfavors minority individuals whenever it obliterates the substitution effect, which favors smaller social groups. If the obliteration of the substitution effect offsets the efficiency benefits of integration, integration *decreases* the relative income of minority individuals.[36] Proposition 10 below states that this is possible in the case of integration from the EI or IE equilibrium into the II equilibrium and that, in particular, integration may increase inequality.[37] It is worthwhile to note that, in contrast to the specialization equilibria, integration produces imperfect substitutability under diversification equilibria and thus benefits minorities in terms of both efficiency and substitution effects.

Proposition 10

There exists I such that integration from the EI or IE equilibrium into the II equilibrium hurts minority individuals in terms of relative earnings, ω, that is, $\omega^{r}(I) > \omega^{II}(I)$ for

[36] Minority individuals benefit from integration relatively more than majority individuals do, as they gain access to social interaction with the larger pool of majority individuals as compared to the access to the smaller group of minority individuals gained by majority individuals.

[37] Forced integration can reduce minority earnings in absolute terms. Intuitively, this is the case whenever social distance is so large as to cause the efficiency benefits of integration to be smaller than its costs in terms of the substitution effect, e.g. when δ is relatively large or ρ relatively small.

$r \in \{EI, IE\}$. Whenever $\rho > \rho'$, there exists I for which integration increases earnings inequality as well.

Proof in the Appendix.

Exclusion in exclusive networks has insofar been accepted in the model as an exogenous institutional constraint on agents' choice. Although it is fully symmetric across social groups, it is sensible to put this constraint under scrutiny, as it may prevent agents from individually benefiting from integration.[38] In particular, it is informative to answer the question whether the explanation of the scale puzzle developed in this chapter remains valid, or, in other words, whether the EI, IE and DI equilibria remain stable, if members of exclusive networks permit inclusion of individuals from the other social group. This is the case, if the excluded agents individually choose not to join exclusive networks of the other social group even if the institutional barriers to integrate are removed. From the proof of Proposition 4 it is clear that this holds whenever minority share in population or social distance is large enough such that the inequality (3.16) is satisfied.[39] It follows that exclusive behavior is not necessary to establish the main results of this study. In particular, equilibria in which segregation and thus skill differentiation across social groups arise are possible without institutional exclusion, giving rise to patterns of income inequality consistent with the scale puzzle as explained above. This argument generalizes the argument of the chapter to societies without institutional exclusion.

3.4.2. Welfare

While the analysis thus far has focused on relative welfare[40] of minority and majority individuals, the various equilibria that the model generates can be welfare ranked according to aggregate consumption C. Given that whether specialization or diversification occurs fully depends on parameters in the condition $\varepsilon \geq (\phi+1)/\phi$, the policy maker cannot choose between

[38] Here I consider marginal deviation from the equilibrium, in which the deviating minority individual can affect her efficiency of skill acquisition (network effects) but not her wage per unit of efficient labor.

[39] Note that marginal deviation to the minority exclusive network would never be beneficial for a majority individual.

[40] Individuals have no income but earnings and consume the same consumption good. Therefore their welfare equals their earnings.

diversification and specialization regimes. Therefore, from the policy perspective it is sensible to compare the efficiency of equilibria within rather than between these regimes.

Proposition 11

Under the specialization regime, the EI and IE equilibria and the EE and IS equilibria are equally efficient. The EI, IE, and II equilibria are more efficient than the EE and IS equilibria. Formally, $C^{EI} = C^{IE}$, $C^{EE} = C^{IS}$, and $C^{r} > C^{r'}$ for $r \in \{EI, IE, II\}$ and $r' \in \{EE, IS\}$. Under the diversification regime, the DI equilibrium is more efficient than the DS equilibrium, that is, $C^{DI} > C^{DS}$.

These results are intuitive and formal proofs are omitted: $C^{EI} = C^{IE}$ and $C^{EE} = C^{IS}$ because all the parameters and inputs in (3.1) are the same under the respective equilibria. The II equilibrium is more efficient than the EE and IS equilibria, because (i) it generates larger inputs $H_k^{II} > H_k^{r}$ for any k and $r \in \{EE, IS\}$ as a consequence of larger network benefits under integration and (ii) production is linear in each of these equilibria. While inputs are the same under EI, IE, EE, and IS equilibria, specialization into different skills under the EI and IE equilibria generates extra surplus in the CES production function (3.1).[41] The same effect favors the DI equilibrium over the DS equilibrium; furthermore, under the DS equilibrium segregation reduces network benefits and thus diminishes labor inputs in production.

The remaining issue concerns the comparison between the EI and IE equilibria on the one hand and the II equilibrium on the other hand. Clearly, this comparison involves weighing benefits of higher efficiency of skill acquisition under integration against the benefits of diversity of inputs in production under segregation. The two key parameters are thus the elasticity of substitution ρ and social distance δ. Intuitively, whenever ρ is very large under the EI and IE equilibria, the benefits of diversity are negligible and thus the II equilibrium is more efficient than the EI and IE equilibria. On the other hand, if δ is very large, integration offers no efficiency benefits and the EI and IE equilibria are preferable to the II equilibrium.

[41] It is a well-known property of the CES function that it exhibits returns to diversity of inputs, for given input levels. These returns are decreasing in ρ for $\rho \in (1, \infty)$.

3.4.3. The Multiplicity of Equilibria

The model presented in this chapter classifies equilibrium regimes of human capital acquisition and elucidates the conditions under which they are stable. Moreover, it pinpoints those equilibria under which minority and majority people acquire different human capitals and identifies the conditions under which they give rise to patterns of earnings inequality consistent with the scale puzzle, which are explicated in Propositions 5 and 9. Table 3.3 below summarizes the equilibria of the model and highlights (bold-typed) those that are reconcilable with the scale puzzle.

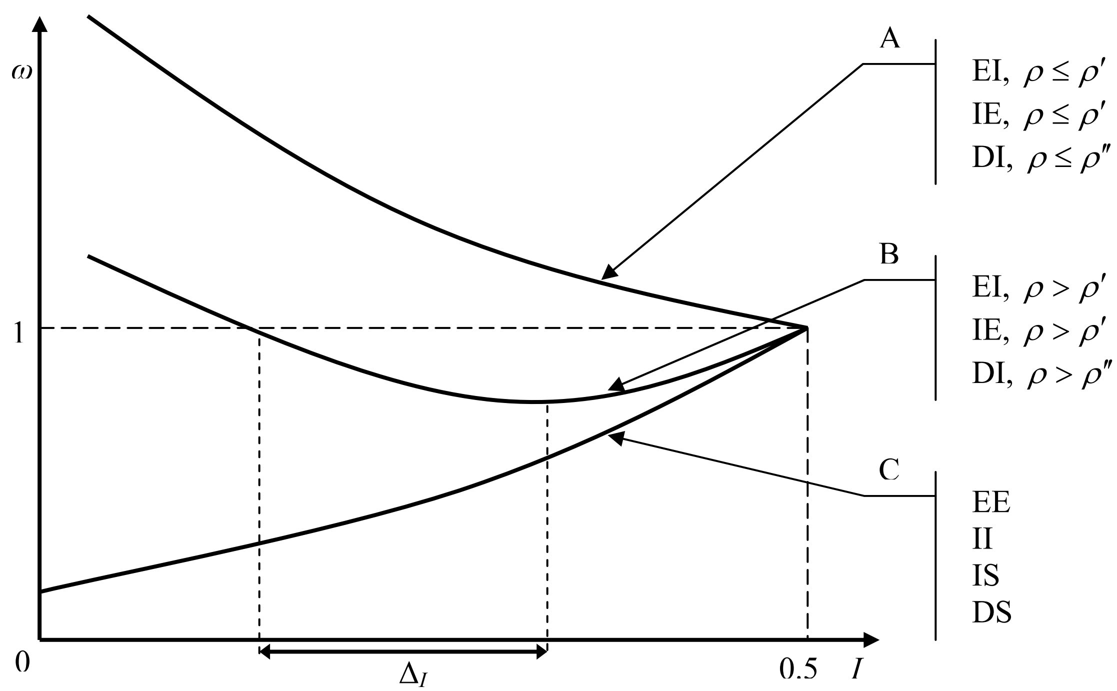
Table 3.3: Equilibrium regimes of skill acquisition.

Regime type	*Stability of equilibria*	
	$I < 1/(2+\delta)$	$I \geq 1/(2+\delta)$
$\varepsilon \geq (\phi+1)/\phi$	EE, II, **IE**	EE, II, IS, **IE**, **EI**
$\varepsilon < (\phi+1)/\phi$	**DI**	**DI**, DS

Table 3.3 shows that the elasticity of substitution between skills in production of efficiency units of labor ε, the degree of decreasing returns to scale in skill acquisition ϕ, social distance between minority and majority δ, and minority share in the population I determine which equilibria may arise in the equilibrium. In particular, the parameters ε and ϕ determine whether specialization or diversification prevails, as depicted in Proposition 2. The other two parameters, δ and I, determine whether segregated equilibria EI, IS, and DS are stable. Notably, Table 3.3 shows that the conditions $I < 1/(2+\delta)$, $\varepsilon < (\phi+1)/\phi$, and $\rho > \rho''$ are sufficient for the patterns of earnings inequality to be consistent with the scale puzzle in some range of I. Whenever either of the conditions $I < 1/(2+\delta)$ or $\varepsilon < (\phi+1)/\phi$ is not satisfied, equilibria EE, II, IS, and DS, which are not reconcilable with the scale puzzle, are possible. Besides these constraints, which equilibrium occurs in any particular case is indeterminate in the model.

This indeterminacy is due to the absence of parametric restriction in the specification of the model, which was intentionally imposed in an attempt to foster its generality. There is, however, an intuitive parametric restriction that lends itself to elimination of some of the equilibria from consideration. In particular, recalling that exclusive skills typically involve those acquired in families, kinships, and other noninstitutional social networks and inclusive skills are predominantly acquired in schools, universities, and workplaces, one can reasonably argue that exclusive and inclusive skills exhibit complementarity such that they both are involved in individual human capital. Indeed, Coleman et al. (1966) argue that students' learning outcome is a function of family and school inputs. Heckman (2000) points out that skills acquired in informal, noninstitutional, sources such as families complement skills acquired in school and other formal institutions and thus determine success in life. If this is the case, one can impose the condition $\varepsilon < (\phi + 1)/\phi$, implying that the model only supports diversification equilibria DI and DS. There are two reasons to believe that the DI equilibrium is somewhat more representative of these two equilibria. First, the DS equilibrium is not robust with respect to coordination of minority individuals to join the inclusive network of majority agents.[42] Second, in Western economies, where efforts are made to eradicate segregation in formal educational institutions, segregation in these institutions is less likely.

Figure 3.1: Stylized patterns of minority-majority earnings inequality.



[42] This straightforwardly follows from the proof of Proposition 6. Note that for similar reasons the equilibria IS and EI are not robust with respect to such coordination; see the proof of Proposition 4.

Figure 3.1 depicts the three stylized patterns of minority-majority earnings inequality as a function of minority percentage that the model generates. Pattern C represents the EE, II, IS, and DS equilibria under which only the efficiency effect is effective. Because the efficiency effect favors larger social groups, pattern C is below one for any $I < 0.5$ and upward sloping. On the other hand, if any of the EI, IE, or, notably, DI equilibrium arises, the substitution effect that favors smaller social groups becomes operative. Pattern A depicts the case when ρ is relatively small such that the substitution effect overrides the efficiency effect to make the minority earn more than the majority for any minority size. The most interesting in the context of the scale puzzle, however, is pattern B. It depicts the intermediate case where the substitution effect works in favor of smaller minorities but does not completely outweigh minorities' efficiency disadvantage such that a range of I where the scale puzzle is replicated by the model, Δ_I, arises. This is so whenever ρ is large enough, as specified in Propositions 5 and 9.

Given that the DI equilibrium is more representative than the DS equilibrium, the remaining question is whether the elasticity of substitution between minority and majority labor ρ is high enough such that a plausible segment Δ_I arises in the model under this equilibrium. To investigate this issue, I tentatively calibrate the model developed above. For this purpose, I let the key parameter ρ attain the value of 25, as estimated by Kahanec (2005). As concerns the remaining parameters, I assume that $\varepsilon = 0.9$, implying a degree of complementarity between exclusive and inclusive skills, $\delta = 0.25$, such that individual's benefit from interaction with a socially distant individual is 80% of that with an akin individual, and $\phi = 1 = \gamma$, such that skill acquisition exhibits constant returns to time and social interaction.[43] With these parametric values the model predicts the segment Δ_I between 0.01% and 5.2%. This range of I covers three quarters of US counties with some Black population.[44] As concerns minority majority earnings gap, under the aforementioned parametric values the ratio of minority to majority earnings attains the minimal value of 0.8 in the labor market with 5.2% of minority people. In other words, in this labor market minority individuals earn about 20% less than majority individuals.

[43] Constant returns are not necessary here, letting $\phi = 0.5$, $\gamma = 0.2$, and holding the other parameters as above, for instance, results in a plausible range of Δ_I between 1.1% and 9.5%.

[44] Author's computation, based on Census School District Tabulation Data, 2000, NCES.

These values correspond to the values of minority-majority earnings gaps found by Kahanec (2005). This exercise illustrates that plausible parametric values give rise to plausible predictions as concerns minority majority earnings differential in the model developed above.

3.5. Conclusion

This chapter provides a novel explanation of the persistent patterns of income inequality between minorities and majorities. In particular, it extends the local effects literature by introducing heterogeneity of available skills into a model with external network effects and minority-majority social distance in human capital acquisition. I establish that such extension provides a theoretical underpinning for the scale puzzle, reconciling the local effects approach with this empirical phenomenon. In particular, I explicate how network effects and social distances in skill acquisition engender the efficiency effect, directly favoring the members of larger social groups. Next, I establish that introducing heterogeneity of available skills into this setup gives rise to equilibria in which minority and majority individuals, driven by network effects, choose different skills or combinations of skills to acquire, thus supplying imperfectly substitutable labor on the labor market. As a consequence, the substitution effect emerges and, through prices of minority and majority labor, favors smaller social groups, which on aggregate supply less labor measured in efficiency units, ceteris paribus. The conditions under which the efficiency and substitution effects explain the scale puzzle are then established and discussed. The last section summarizes and classifies the outcomes of the model, offering a tool to address the various modes of minority-majority interaction observed in the reality.

Highlighting the role of segregation, the chapter discusses the consequences of segregation on the efficiency of skill acquisition and relative wages. It is also shown that elimination of institutional exclusion in social networks does not necessarily lead to integration whenever the size of minority or the social distance between social groups is large enough. An interesting result of the model is that integration may increase as well as decrease the relative income of minority as compared to majority individuals. In this sense, although there are efficiency benefits of integration for both minority and majority individuals, integration is not necessarily a universal remedy against inequality between social groups. Similarly, integration may increase as well as decrease overall welfare. The model also predicts that under some conditions for a small minority the substitution effect outweighs minority's efficiency disadvantage such that minority earnings are higher than majority earnings. No discrimination on the labor market is necessary to obtain the results of this chapter, which makes it an alternative to the existing discrimination-based theories of earnings inequality. Future research in this area should include empirical tests and case studies, as well as investigation of the link between organization of social interaction and, first, geographical location and, second, the dynamics of social distance.

Appendix to Chapter 3

Table 3A.1: The scale puzzle – empirical evidence.

Study	*Data*	*Main Findings*
Blalock (1956)	88 non-Southern and Southern Standard Metropolitan Areas (SMAs), (1950)	Finds a positive correlation .42 between percent Black population and Black-White income differentials. Controlling for subregion, white median income, size of SMA, and percent of employed males in manufacturing, the correlation was reduced to nonsignificant .19. However, for southern SMAs the correlation was .50 and increased to .70 when the same controls were included. When both Southern and non-Southern SMAs were included, the correlation was .67 irrespective of the controls. Suggests that the marginal Black relative losses due to percent increase are decreasing (non-linearity) in percent Black. Suspects a threshold at about 10% above which correlations significant.
Blalock (1957)	Sample of 150 Southern US counties having at least 250 non-white households, (1950)	Finds a positive correlation between percent Black population and income (.46) and educational (.68) differentials. The findings were robust with respect to the same controls as in Blalock (1956). Finds that in counties with low Black percentage (but not in those with high Black percentage where all results were non-significant) the income and educational gaps are disproportionaly smaller, thereby supporting the non-linearity hypothesis for the low end of the density continuum. No relationship is observed for occupational differentials.
Heer (1959)	43 Southern Standard Metropolitan Areas, Census, (1950)	Finds negative correlation of -.71 between percent Black and the ratio of Black median income to White median income.
Brown and Fuguitt (1972)	878 non-metropolitan areas, Southern US, PH-5 census, (1960)	Report overrepresentation of the majority in all higher income groups (difference scores range between 31% and 45% when cumulative distributions are compared). Find that the association between percent Black and measures of racial income disparity is positive and ranges between .16 and .41. Moreover, they show that Black income decreases and White income increases with increases in percent Black. White component correlations range between .12 and .21. Black counterparts range between -.09 and -.31.
Frisbie and Neidert (1977)	40 Standard Metropolitan Areas in southwestern U.S. U.S. Bureau of the Census, (1971, 1972)	Report overrepresentation of the majority in all higher income groups (difference scores range between 7% and 20% (Mexican) and between 18% and 31% (Black) when cumulative distributions are compared). Finds correlations of .22 to .48 between percent Mexican and the Mexican-Anglo income differential for different income groups. The corresponding values for the Blacks range between 0.31 and 0.43. Controls included: % labor force in manufacturing, % labor force in services, Black median education, 1960-1970 % change in Black population, % Mexican. Uncontrolled correlations similar. Confirms that the majority income is positively correlated with percent minority (correlations between .06 and .21) and that minority income is negatively correlated with percent minority (correlations between -.48 and -.22).
Tienda and Lii (1987)	5% A File, men, Public Use Microdata Samples, Census (1980)	Confirms that minorities have lower income than majorities and that minorities lose from increases in their percentages, while the white majority gains. Blacks, Hispanics, and Asians lose 0.7%, 0.2%, and $0.2% of their annual income, respectively, and the majority gains between 0.0-0.5% with every percentage increase of the respective minority density. These results are net of some observable individual characteristics and working time measures. Minority losses from their percentages most pronounced for educated minority people.
Borjas (1987)	5% A File, 18-64 years old non-military individuals working with pay, Public Use Microdata Samples, Census (1980)	Shows that while native populations' earnings are little decreased by inflow of immigrants of the same ethnicity (e.g. 10% increase in the supply of White immigrants decreases the pay of White natives by 2.5%), this inflow substantially reduces the earnings of other immigrants of the same ethnicity (10% increase in the number of White immigrants reduces the pay of white immigrants by 10.9%, the same increase of Black immigration reduces the pay of Black immigrants by 5.8%).
Chiswick and Miller, (2005)	US Census of Population (1990)	Establish that earnings of immigrants of a given linguistic group decrease in the share of people of the same linguistic group in the destination region.

Proof of Time Allocation Rule (3.8)

Take the allocation of time $\{T_{k,x}, T_{k,n}\}$ as given and rewrite the agents' problem (3.7) as follows:

$$\underset{L_{k,m}}{Max}\left|H_k\right|$$
$$s.t.$$
$$H_k = \left(\left(S_{k,x}\left(T_{k,x} - L_{k,x}\right)\right)^{(\varepsilon-1)/\varepsilon} + \left(S_{k,n}\left(T_{k,n} - L_{k,n}\right)\right)^{(\varepsilon-1)/\varepsilon}\right)^{\varepsilon/(\varepsilon-1)}$$
$$S_{k,m} = L_{k,m}^{\phi}\left(1 + N_{k,m}\right)$$
$$L_{k,m} \geq 0$$

Plugging the technological constraints into the objective function and deriving the first order conditions with respect to $L_{k,m}$, the optimality conditions on time distribution between acquisition and utilization of skills are $L_{k,m} = \frac{\phi}{1+\phi}T_{k,m}$. The sufficiency conditions are also satisfied, as the objective function is concave at the optimal allocation. ■

Proof of Proposition 1

Substitute for $L_{k,m}$ in the agent's problem (3.7) using (3.8). In addition, substitute for $S_{k,m}$ from the skill acquisition technology and use the definition of $\widetilde{N}_{k,m}$. Consequently, the agent's problem is:

$$\underset{T_{k,x},T_{k,n}}{Max}\left|\left(\widetilde{N}_{k,x}T_{k,x}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}} + \widetilde{N}_{k,n}T_{k,n}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}}\right)^{\varepsilon/(\varepsilon-1)}\right|$$
$$s.t.$$
$$T_{k,x} + T_{k,n} \leq 1$$
$$T_{k,m} \geq 0$$

Note that if $\varepsilon = (\phi+1)/\phi > 1$ the problem boils down to

$$\underset{T_{k,x},T_{k,n}}{Max}\left|\left(\widetilde{N}_{k,x}T_{k,x} + \widetilde{N}_{k,n}T_{k,n}\right)^{\varepsilon/(\varepsilon-1)}\right|$$
$$s.t.$$
$$T_{k,x} + T_{k,n} \leq 1$$
$$T_{k,m} \geq 0$$

and, obviously, the maximum is the corner solution with the higher $\widetilde{N}_{k,m}$.

Now assume $\varepsilon \neq (\phi+1)/\phi$. Form the Kuhn-Tucker Lagrangian $L(\bullet) = \left(\widetilde{N}_{k,x}T_{k,x}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}} + \widetilde{N}_{k,n}T_{k,n}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}}\right)^{\varepsilon/(\varepsilon-1)} - \lambda\left(T_{k,x} + T_{k,n} - 1\right)$ to obtain the first order Kuhn-Tucker conditions for a maximum

$$\widetilde{N}_{k,x}(1+\phi)T_{k,x}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}H_k-\lambda\leq 0$$
$$\widetilde{N}_{k,n}(1+\phi)T_{k,n}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}H_k-\lambda\leq 0$$
$$T_{k,x}\left(\widetilde{N}_{k,x}(1+\phi)T_{k,x}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}H_k-\lambda\right)=0$$
$$T_{k,n}\left(\widetilde{N}_{k,n}(1+\phi)T_{k,n}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}H_k-\lambda\right)=0$$
$$1-T_{k,x}-T_{k,n}\geq 0$$
$$\lambda\left(1-T_{k,x}-T_{k,n}\right)=0$$

First realize that $H_k \geq 0$, $H_k^* > 0$, and that both H_k and H_k^* are finite, for any admissible parametric values on the constrained domain. The finiteness follows from the limited time resources and the fact that, for any admissible parametric values, the production technology of efficient labor does not permit infinite output with limited resources. Moreover, it is always possible to allocate some resources to production of efficient labor such that it is positive and thus $H_k^* > 0$. To satisfy the first two Kuhn-Tucker conditions, λ must be positive, otherwise both $T_{k,x}$ and $T_{k,n}$ would have to be zero implying $H_k^* = 0$, which is inadmissible. Therefore, the time constraint is binding.

Now let us use the Kuhn-Tucker conditions to study the corner solution $T_{k,x} = 0$ and $T_{k,n} = 1$. Realizing that $\left(\widetilde{N}_{k,n}(1+\phi)T_{k,n}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}H_k-\lambda=0\wedge\{T_{k,x},T_{k,n}\}=\{0,1\}\right)\Rightarrow\widetilde{N}_{k,n}(1+\phi)H_k=\lambda>0$. Because both $\widetilde{N}_{k,n}$ and H_k are finite, λ is finite as well. Substituting for λ, $\widetilde{N}_{k,x}(1+\phi)T_{k,x}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}H_k-\lambda\leq 0\Leftrightarrow\widetilde{N}_{k,x}T_{k,x}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}-\widetilde{N}_{k,n}\leq 0$. Because $T_{k,x}$=0 and $\widetilde{N}_{k,x}T_{k,x}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}-\widetilde{N}_{k,n}\leq 0$, it follows that $\widetilde{N}_{k,x}T_{k,x}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}$ is finite (and well defined). This is the case whenever the exponent is larger than zero, that is, whenever $\varepsilon > (\phi+1)/\phi$. This condition is thus the necessary condition for the studied corner solution to be the maximum. By symmetry, the same necessary condition must hold for the corner solution $T_{k,n} = 0$ then $T_{k,x} = 1$ to be the maximum.

If $T_{k,x} > 0$ and $T_{k,n} > 0$, in the interior solution, the first two Kuhn-Tucker conditions are equalities and the following result is obtained:

$$\widetilde{N}_{k,x}(1+\phi)T_{k,x}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}} H_k - \lambda = 0 \wedge \widetilde{N}_{k,n}(1+\phi)T_{k,n}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}} H_k - \lambda = 0 \Rightarrow$$

$$1 = \frac{\lambda}{\lambda} = \frac{\widetilde{N}_{k,x}T_{k,x}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}}{\widetilde{N}_{k,n}T_{k,n}^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}} = \frac{\widetilde{N}_{k,x}}{\widetilde{N}_{k,n}}\left(\frac{T_{k,x}}{T_{k,n}}\right)^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}} = \left(\frac{1+N_{k,x}}{1+N_{k,n}}\right)^{(\varepsilon-1)/\varepsilon}\left(\frac{T_{k,x}}{T_{k,n}}\right)^{\frac{\phi\varepsilon-\phi-1}{\varepsilon}}$$

It follows that $\frac{T_{k,x}}{T_{k,n}} = \left(\frac{1+N_{k,x}}{1+N_{k,n}}\right)^{\frac{\varepsilon-1}{1+\phi-\varepsilon\phi}}$. Using this result and the time constraint it follows that $T_{k,x} = t_k/(1+t_k)$ and $T_{k,n} = 1/(1+t_k)$.

Consequently, there are three possible candidates for the maximum, two corner solutions and one interior solution. Given the results above, evaluating the objective function at each of these candidates, the values of H_k at the candidate time allocations are

$$H_k\Big|_{T_{k,x}=\frac{t_k}{1+t_k},T_{k,n}=\frac{1}{1+t_k}}\left(\frac{t_k}{1+t_k},\frac{1}{1+t_k}\right) = \left(\widetilde{N}_{k,x}\left(\frac{t_k}{1+t_k}\right)^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}} + \widetilde{N}_{k,n}\left(\frac{1}{1+t_k}\right)^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}}\right)^{\varepsilon/(\varepsilon-1)}$$

$$H_k\Big|_{T_{k,x}=0,T_{k,n}=1} = \left(\widetilde{N}_{k,x}T_{k,x}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}} + \widetilde{N}_{n}T_{k,n}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}}\right)^{\varepsilon/(\varepsilon-1)} = \widetilde{N}_{k,n}^{\varepsilon/(\varepsilon-1)}$$

$$H_k\Big|_{T_{k,x}=1,T_{k,n}=0} = \left(\widetilde{N}_{k,x}T_{k,x}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}} + \widetilde{N}_{k,n}T_{k,n}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}}\right)^{\varepsilon/(\varepsilon-1)} = \widetilde{N}_{k,x}^{\varepsilon/(\varepsilon-1)}$$

Now I verify the sufficient conditions for each of these candidates to be the maximum. Note that from the Kuhn-Tucker first order conditions the time constraint is binding and therefore we can rewrite the agent's problem in the following way

$$\underset{T_{k,x}}{Max}\left|\left(\widetilde{N}_{k,x}T_{k,x}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}} + \widetilde{N}_{k,n}(1-T_{k,x})^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}}\right)^{\varepsilon/(\varepsilon-1)}\right|$$

$$s.t.$$

$$1 \geq T_{k,x} \geq 0$$

Consider the new objective function on the constrained domain. Differentiate the objective function to obtain

$$\frac{\partial^2\left(\left(\widetilde{N}_{k,x}T_{k,x}^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}}+\widetilde{N}_{k,n}\left(1-T_{k,x}\right)^{(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}}\right)^{\varepsilon/(\varepsilon-1)}\right)}{\partial T_{k,x}^2}=$$

$$\frac{(1+\phi)H_k\left(-\widetilde{N}_{k,x}\widetilde{N}_{k,n}(\phi\varepsilon-\phi-1)\left(1-T_{k,x}\right)^{\frac{1+\phi}{\varepsilon}}\left(T_{k,x}\left(1-T_{k,x}\right)\right)^{\phi}T_{k,x}^{\frac{1+\phi}{\varepsilon}}-\varepsilon\phi\left(1-T_{k,x}\right)T_{k,x}\left(\widetilde{N}_{k,x}T_{k,x}^{\phi}\left(1-T_{k,x}\right)^{\frac{\phi+1}{\varepsilon}}-\widetilde{N}_{k,n}\left(1-T_{k,x}\right)^{\phi}T_{k,x}^{\frac{\phi+1}{\varepsilon}}\right)^2\right)}{-\varepsilon\left(1-T_{k,x}\right)T_{k,x}\left(\widetilde{N}_{k,x}T_{k,x}^{\phi+1}\left(1-T_{k,x}\right)^{\frac{\phi+1}{\varepsilon}}+\widetilde{N}_{k,n}\left(1-T_{k,x}\right)^{\phi+1}T_{k,x}^{\frac{\phi+1}{\varepsilon}}\right)^2}$$

Now it is straightforward to see that

$$Sign\left\{\frac{\partial^2 H_k}{\partial T_{k,x}^2}\right\}=Sign\left\{\widetilde{N}_{k,x}\widetilde{N}_{k,n}(\phi\varepsilon-\phi-1)\left(1-T_{k,x}\right)^{\frac{1+\phi}{\varepsilon}}\left(T_{k,x}\left(1-T_{k,x}\right)\right)^{\phi}T_{k,x}^{\frac{1+\phi}{\varepsilon}}+\varepsilon\phi\left(1-T_{k,x}\right)T_{k,x}\left(\widetilde{N}_{k,x}T_{k,x}^{\phi}\left(1-T_{k,x}\right)^{\frac{\phi+1}{\varepsilon}}-\widetilde{N}_{k,n}\left(1-T_{k,x}\right)^{\phi}T_{k,x}^{\frac{\phi+1}{\varepsilon}}\right)^2\right\}$$

and that the term on the right hand side has a positive sign for any $1 > T_{k,x} > 0$ whenever $\phi\varepsilon - \phi - 1 > 0 \Leftrightarrow \varepsilon > (\phi+1)/\phi$. Thus, the interior solution cannot be the maximum if $\varepsilon > (\phi+1)/\phi$. As argued above, the objective function is certainly continuous and bounded on the constrained domain. Therefore, there must exist a maximum. Having excluded the interior candidate, the corner solution with the higher $\widetilde{N}_{k,m}$ and thus $\widetilde{N}_{k,m}^{\varepsilon/(\varepsilon-1)}$ is the maximum on the constrained domain.

From the Kuhn-Tucker conditions we know that if $\varepsilon < (\phi+1)/\phi$, none of the corner candidates can be the maximum. As above, because the objective function is continuous and bounded on the constrained domain, there must exist a maximum. Being the only remaining possibility, the interior solution is the maximum and $H_k^* = H_k\left(t_k/(1+t_k), 1/(1+t_k)\right)$ whenever $\varepsilon < (\phi+1)/\phi$. For the implication in (3.9a-b), note that $\varepsilon/(\varepsilon-1) > 0$. This completes the proof.[45] ■

Proof of Proposition 2

Individuals invest their time in those social networks of a given type, exclusive or inclusive, that offer the largest network effects and thus are the most efficient for acquiring that type of skill. Assume there is an equilibrium with an individual violating the proposition thus involved in two networks of a given type, splitting his time between these networks. It must then be that the network effects in these two networks are the same for this individual; otherwise he would pick the one that is more efficient to spend his time. Such equilibrium is unstable, however. Given that network effects increase in agents' involvements, any marginal deviation in allocation of agents causes the network effects between the two networks to differ and, as a consequence, the agent to abandon the less efficient network. Obviously, the reaction of the other individuals to

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[45] A simpler way to determine which of the three candidates is the maximum is possible, noting that $(\phi+1)\frac{(\varepsilon-1)}{\varepsilon}$ and $\frac{\varepsilon}{(\varepsilon-1)}$ fully determine the properties of the maximization problem. The lengthier and more formal approach was adopted here.

such marginal deviation does not stabilize the equilibrium, as network effects are increasing in individual involvements. ■

Proof of Proposition 3

Given the asymmetric information on the labor market, individuals take the wage for the unit of their efficient labor as given with respect to their choice of skills. Therefore, individuals pick that combination of social networks and thus skills that is the most efficient in production of efficient labor. To prove Proposition 3 by contradiction, assume there is an equilibrium with two individuals from a given social group that are involved in two different combinations of social networks. Because the two individuals are free to choose between networks, in this equilibrium it must be that the efficiencies of these two combinations of social networks for the two individuals in production of efficient labor are the same. Such equilibrium is, however, unstable. Any marginal deviation from the equilibrium agent involvements across these two different combinations of networks causes their efficiencies to differ. As a result, the agent involved in the less efficient set of social networks switches to the more efficient one. As above, the reaction of the other individuals to the marginal deviations does not stabilize the equilibrium. ■

Proof of Proposition 4

Recall that, due to asymmetric information, employers differentiate wages per unit of efficient labor across social groups but not within groups and that individuals cannot change their group membership. Therefore, agents pick those networks to acquire skills that they are allowed to join and that offer the largest network effect benefits (and thus are the most efficient in skill acquisition). Applying (3.8) to network effect specification in (3.14) and (3.15), the network effects are:

$$N^r_{i,m}(I^r_m L_{i,m}, J^r_m L_{j,m}, \delta) = \left(I^r_m + \frac{1}{1+\delta} J^r_m\right)^{\gamma} \left(\frac{\phi}{1+\phi}\right)^{\gamma}$$

$$N^r_{j,m}(I^r_m L_{i,m}, J^r_m L_{j,m}, \delta) = \left(\frac{1}{1+\delta} I^r_m + J^r_m\right)^{\gamma} \left(\frac{\phi}{1+\phi}\right)^{\gamma}$$

where the superscript $r \in \{EE, II, EI, IE\}$ denotes the prevailing equilibrium.

As a first step, recalling Proposition 3 and its proof, note that deviation to an empty social network is never beneficial and for any individual it is preferable to be a member of the social network populated by the other members of her social group. Now let us consider deviations that are permitted and that involve switching to a non-empty social network, equilibrium by equilibrium.

As concerns the EE equilibrium, there is no permissible deviation to a non-empty social network. IT is thus always stable. The same holds for the II equilibrium.

Now investigate the IE equilibrium. Under this equilibrium a majority individual could switch to a minority inclusive network, which is non-empty. For such marginal deviation not to occur, the stability condition is $N^{IE}_{j,x} \geq N^{IE}_{j,n}$. Now note that $N^{IE}_{j,x} = J^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}$ and $N^{IE}_{j,n} = \left(1/(1+\delta)I\right)^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}$. Thus, the stability condition is equivalent to $J \geq I/(1+\delta)$, which always holds and the IE equilibrium is always stable.

As concerns the EI equilibrium, the argument is similar to the one just above. The possible deviation now involves minority individuals who compare $N_{i,x}^{EI} = I^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}$ and $N_{i,n}^{EI} = \left(J/(1+\delta)\right)^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}$. This yields the condition $I \geq J/(1+\delta)$, which holds, if the minority (or social distance) is large enough.

Now consider the IS equilibrium. In any stable IS equilibrium it must be that agents prefer staying in the inclusive networks occupied by their own social group, enjoying network effects $N_{i,n}^{IS} = I^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}$ and $N_{j,n}^{IS} = J^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}$, to deviating to the inclusive social network composed of the members of the other social group and obtaining network benefits $\frac{1}{1+\delta}J^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}$ and $\frac{1}{1+\delta}I^{\gamma}\left(\phi/(1+\phi)\right)^{\gamma}$, respectively. These conditions hold if and only if $I \geq J/(1+\delta)$ and $J \geq I/(1+\delta)$, of which the second is always satisfied. Because $I + J = 1$, $I \geq J/(1+\delta) \Leftrightarrow I \geq 1/(2+\delta)$. ■

Proof of Proposition 5 (superscripts omitted)

Recall that $I + J = 1$. Realize that the $\omega(I)$ curve is continuous for any $I > 0$ and continuous from the right at $I = 0$. The proof consists of three steps. First, note that whenever ρ is finite, $\omega(I)$ approaches infinity as $I \to 0$, $\underset{I\to 0}{Lim}(\omega(I)) = \infty$. Second, realize that by symmetry $\omega(I) = 1$ at $I = 0.5$. In the last step tedious algebraic manipulations (partial differentiation of $\omega(I)$ with respect to *I*, computations omitted) yield that whenever the parametric condition $\left(\phi/(1+\phi)\right)^{\gamma}(\rho\gamma - \gamma - 1) > 2^{\gamma}$ is satisfied the $\omega(I)$ curve is upward sloping at $I = 0.5$. In consequence, the continuous $\omega(I)$ curve lies above one at $I \to 0$ and has a positive slope at the point $\omega(0.5) = 1$ if the above parametric condition holds. As a result, under the IE equilibrium there always is a range of *I* where $\omega(I) < 1$ and $\partial\omega(I)/\partial I < 0$. The same is true under the EI equilibrium if social distance δ is large enough such that for some *I* from this range the EI equilibrium is stable. This is the case for any $\delta \geq 1/I - 2$ for *I* from such range, which is well defined, and for $\delta \to \infty$ in particular. Simple algebra shows that the parametric condition above is satisfied for all $\rho > \rho'$, where $\rho' \equiv \left(\left(2(\phi+1)/\phi\right)^{\gamma} + \gamma + 1\right)/\gamma > 0$. ■

Proof of Proposition 6

Recall that agents always pick those networks to acquire skills that they are allowed to join and that offer the largest network effects and thus are the most efficient. The only possibility for an individual to deviate in the equilibrium where both social groups acquire inclusive skills in one inclusive social network is to form his own inclusive social network. Because such network would offer zero network benefits, as compared to positive network benefits in the integrated inclusive network, such deviation is never profitable and therefore the equilibrium is stable.

If, on the other hand, inclusive skills are acquired in two segregated inclusive networks, for this equilibrium to be stable it must be that all individuals prefer staying in the inclusive networks occupied by their own social group, enjoying network effects $N_{i,n}^{DS} = I^{\gamma}$ and $N_{j,n}^{DS} = J^{\gamma}$, to deviating to the inclusive social network of the other social group and obtaining network benefits

$\frac{1}{1+\delta}J^{\gamma}$ and $\frac{1}{1+\delta}I^{\gamma}$, respectively. These conditions hold if and only if $I \geq \frac{1}{1+\delta}J$ and $J \geq \frac{1}{1+\delta}I$, of which the second is always satisfied. Note that because $I+J=1$, $I \geq \frac{1}{1+\delta}J \Leftrightarrow I \geq \frac{1}{2+\delta}$. ■

Proof of Proposition 7 and Proposition 8

First note that:

$$I<\frac{1}{2} \Leftrightarrow \left(\frac{1}{1+\delta}\frac{I}{(1-I)}+1\right)^{\gamma} < \left(1+\frac{1}{1+\delta}\frac{(1-I)}{I}\right)^{\gamma} \Leftrightarrow \frac{1+\left(\frac{1}{1+\delta}I+(1-I)\right)^{\gamma}}{1+\left(I+\frac{1}{1+\delta}(1-I)\right)^{\gamma}} =$$

$$= \frac{1+(1-I)^{\gamma}\left(\frac{1}{1+\delta}\frac{I}{(1-I)}+1\right)^{\gamma}}{1+I^{\gamma}\left(1+\frac{1}{1+\delta}\frac{(1-I)}{I}\right)^{\gamma}} < \frac{1+(1-I)^{\gamma}}{1+I^{\gamma}} \Leftrightarrow \frac{1+I^{\gamma}}{1+(1-I)^{\gamma}}\frac{1+\left(\frac{1}{1+\delta}I+(1-I)\right)^{\gamma}}{1+\left(I+\frac{1}{1+\delta}(1-I)\right)^{\gamma}} < 1$$

which yields:

1) $$\left(\frac{1+I^{\gamma}}{1+(1-I)^{\gamma}}\frac{1+\left(\frac{1}{1+\delta}I+(1-I)\right)^{\gamma}}{1+\left(I+\frac{1}{1+\delta}(1-I)\right)^{\gamma}}\right)^{\frac{\varepsilon-1}{1+\phi-\varepsilon\phi}} = \frac{t_i^{DI}}{t_j^{DI}} = \frac{l_i^{DI}}{l_j^{DI}} > 1 \Leftrightarrow \frac{\varepsilon-1}{1+\phi-\varepsilon\phi} < 1 \Leftarrow \varepsilon < 1 \wedge \varepsilon < (1+\phi)/\phi$$

2) $$\frac{t_i^{DI}}{t_j^{DI}} = \frac{l_i^{DI}}{l_j^{DI}} < 1 \Leftrightarrow \frac{\varepsilon-1}{1+\phi-\varepsilon\phi} > 1 \Leftarrow \varepsilon > 1 \wedge \varepsilon < (1+\phi)/\phi$$

3) $$\frac{t_i^{DI}}{t_j^{DI}} = \frac{l_i^{DI}}{l_j^{DI}} = 1 \Leftrightarrow \frac{\varepsilon-1}{1+\phi-\varepsilon\phi} = 0 \Leftarrow \varepsilon = 1 \wedge \varepsilon < (1+\phi)/\phi$$

4) $$\left(\frac{1+I^{\gamma}}{1+(1-I)^{\gamma}}\frac{1+\left(\frac{1}{1+\delta}I+(1-I)\right)^{\gamma}}{1+\left(I+\frac{1}{1+\delta}(1-I)\right)^{\gamma}}\right)^{\frac{1}{1+\phi-\varepsilon\phi}} = \frac{S_{i,x}^{DI}}{S_{i,n}^{DI}} \Big/ \frac{S_{j,x}^{DI}}{S_{j,n}^{DI}} < 1 \quad \forall \varepsilon < (1+\phi)/\phi$$

This completes the proof. ■

Proof of Proposition 9 (superscripts omitted)

To prove this proposition, I state and prove the following lemma:

Lemma 1:
There always exists $I > 0$ such that $h(I) < 1$.

Proof of Lemma 1
If $\delta \to \infty$, one obtains that $H_i(I)\big|_{I\to 0} < H_j(I)\big|_{I\to 0}$ directly from the inequality $H_i(I)\big|_{I\to 0,\delta\to\infty} = 2^{\frac{\varepsilon}{\varepsilon-1}-\phi-1} < 2^{\frac{\varepsilon}{\varepsilon-1}-\phi} = H_j(I)\big|_{I\to 0,\delta\to\infty}$. For the case of finite δ, in the first step I prove that $H_i(I)\big|_{I\to 0} < H_j(I)\big|_{I\to 0}$ and both are well defined if $\varepsilon \neq 1$. Using (3.5), (3.6), (3.18a-b), and the specifications of network effects under the DI equilibrium:

$$H_i(I)\big|_{I\to 0} = \left(1+\left(\frac{1}{1+(1/(1+\delta))^{\gamma}}\right)^{\frac{1-\varepsilon}{\phi\varepsilon-\phi-1}}\right)^{-1-\phi}\left(\left(\left(\left(\frac{1}{1+(1/(1+\delta))^{\gamma}}\right)^{\frac{1-\varepsilon}{\phi\varepsilon-\phi-1}}\right)^{1+\phi}\right)^{\frac{\varepsilon-1}{\varepsilon}}+\left(1+\left(\frac{1}{1+\delta}\right)^{\gamma}\right)^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}}$$

After some algebra one obtains $H_i(I)\big|_{I\to 0} = \left(1+\left(\frac{1}{1+\delta}\right)^{\gamma}\right)\left(\left(1+\left(\frac{1}{1+\delta}\right)^{\gamma}\right)^{\frac{\varepsilon-1}{\phi\varepsilon-\phi-1}}+1\right)^{\frac{1}{\varepsilon-1}-\phi}$. Now, noting that $1 \le \left(1+\left(\frac{1}{1+\delta}\right)^{\gamma}\right) \le 2$, one obtains that:

$$H_i(I)\big|_{I\to 0} = \left(1+\left(\frac{1}{1+\delta}\right)^{\gamma}\right)\left(\left(1+\left(\frac{1}{1+\delta}\right)^{\gamma}\right)^{\frac{\varepsilon-1}{\phi\varepsilon-\phi-1}}+1\right)^{\frac{1}{\varepsilon-1}-\phi} \le 2\left(\left(1+\left(\frac{1}{1+\delta}\right)^{\gamma}\right)^{\frac{\varepsilon-1}{\phi\varepsilon-\phi-1}}+1\right)^{\frac{1}{\varepsilon-1}-\phi}.$$

It is easy to see that $H_j(I)\big|_{I\to 0} = 2^{\frac{\varepsilon}{\varepsilon-1}-\phi}$. Having these results, the condition

$$\left(\left(1+(1/(1+\delta))^{\gamma}\right)^{\frac{\varepsilon-1}{\phi\varepsilon-\phi-1}}+1\right)^{\frac{1}{\varepsilon-1}-\phi} < 2^{\frac{1}{\varepsilon-1}-\phi} \qquad (3A.1)$$

implies $H_i(I)\big|_{I\to 0} < H_j(I)\big|_{I\to 0}$. Realize now that the diversification condition $\varepsilon < (\phi+1)/\phi$ is equivalent to: $\left((\varepsilon > 1)\wedge\left(\frac{1}{\varepsilon-1}-\phi > 0\right)\right)\vee\left((\varepsilon < 1)\wedge\left(\frac{1}{\varepsilon-1}-\phi < 0\right)\right)\vee \varepsilon = 1$, defining three cases when the diversification condition is satisfied. Since the last one is excluded in the proposition, let us consider the first two, denoting them Case A and Case B.

Consider Case A when $(\varepsilon > 1) \wedge \left(\frac{1}{\varepsilon - 1} - \phi > 0 \right)$. Due to the second inequality and noting that in (3A.1) it holds that $\left(1+\left(\frac{1}{1+\delta}\right)^{\gamma}\right)^{\frac{\varepsilon-1}{\phi\varepsilon-\phi-1}}+1 \geq 1$, one can take away the powers without changing the inequality in (3A.1). Accordingly, rewrite (3A.1) as follows: $\left(1+\left(\frac{1}{1+\delta}\right)^{\gamma}\right)^{\frac{\varepsilon-1}{\phi\varepsilon-\phi-1}} < 1$ and realize that $\frac{\varepsilon-1}{\phi\varepsilon-\phi-1} < 0$. It follows that for finite δ it holds that $1+\left(\frac{1}{1+\delta}\right)^{\gamma} > 1$ and thus (3A.1) holds, which implies that $H_i(I)\big|_{I\to 0} < H_j(I)\big|_{I\to 0}$.

Consider now Case B where $(\varepsilon < 1) \wedge \left(\frac{1}{\varepsilon - 1} - \phi < 0 \right)$. As in Case A, we can take away the powers but the direction of the inequality must be changed because of the powers are now negative. Thus, we can rewrite the inequality in (3A.1) as follows: $\left(1+\left(\frac{1}{1+\delta}\right)^{\gamma}\right)^{\frac{\varepsilon-1}{\phi\varepsilon-\phi-1}} > 1$. Now realize that $\frac{\varepsilon-1}{\phi\varepsilon-\phi-1} > 0$. This inequality and that $1+\left(\frac{1}{1+\delta}\right)^{\gamma} > 1$ for any finite δ prove that (3A.1) holds and that $H_i(I)\big|_{I\to 0} < H_j(I)\big|_{I\to 0}$ in Case B as well.

Realizing that, by symmetry, $H_i(I)\big|_{I\to 0.5} = H_j(I)\big|_{I\to 0.5}$ and $h(I)$ is continuous for any $I \geq 0$, there exists $I > 0$ such that $H_i(I) < H_j(I)$ and thus $h(I) < 1$ for any admissible parametric values. Denote Γ_I the set of all such I.

If $\varepsilon = 1$ such that $H_k = \left(\left(\frac{\phi}{1+\phi}\right)^{\phi} T_{k,x}^{\phi+1}\left(1+N_{k,x}\right)\left(1-\frac{\phi}{1+\phi}\right)\right)^{1/2}\left(\left(\frac{\phi}{1+\phi}\right)^{\phi} T_{k,n}^{\phi+1}\left(1+N_{k,n}\right)\left(1-\frac{\phi}{1+\phi}\right)\right)^{1/2}$, $h = \frac{\left(1+N_{i,x}\right)^{1/2}\left(1+N_{i,n}\right)^{1/2}}{\left(1+N_{j,x}\right)^{1/2}\left(1+N_{j,n}\right)^{1/2}}$. Evidently, network effects are larger for the majority and thus $h < 1$ whenever $\varepsilon = 1$. This completes the proof of Lemma 1.

Now recall that $\omega(I) = \left(\frac{I}{1-I}h(I)\right)^{\frac{-1}{\rho}} h(I)$. Because $\underset{\rho\to\infty}{Lim}\left(\left(\frac{I}{1-I}h(I)\right)^{\frac{-1}{\rho}}\right) = 1$ and $\left(\frac{I}{1-I}h(I)\right)^{\frac{-1}{\rho}}$ is a decreasing continuous function of ρ for any $I \in (0,0.5)$, there always exists ρ large enough such that $\omega(I) < 1$ for some $I \in \Gamma_I$. In particular, it can be shown that for any

$\rho > \rho'' \equiv \underset{I \in \Gamma_I}{Min} \left| Log\left(\frac{I}{(1-I)} h(I) \right) \Big/ Log(h(I)) \right|$ it holds that $\omega(I) < 1$ for some $I \in \Gamma_I$. Straightforwardly, ρ'' is well defined for any $I \in (0,1)$ and is positive and finite.

Similarly to the proof of Proposition 5, $\omega(I)$ is continuous for all $I \in (0,1)$, approaches infinity as *I* approaches zero, and $\omega(I) = 1$ for $I = 0.5$. Adding the fact that for $\rho > \rho''$, there is *I* such that $\omega(I) < 1$ suffices to ensure that there always is a range of *I* where $\omega(I) < 1$ and $\partial\omega(I)/\partial I < 0$. This completes the proof. ■

Proof of Proposition 10

Because $\omega^{II}(I) < 1$ and there always exists *I* such that $\omega^{EI}(I) = \omega^{IE}(I) > 1$ (c.f. Proof of Proposition 5), it must be that $\omega^{EI}(I) = \omega^{IE}(I) > \omega^{II}(I)$ for some *I*. This proves the first part. Moreover, if $\rho > \rho' \equiv \left(\left(2(\phi+1)/\phi \right)^{\gamma} + \gamma + 1 \right) \gamma^{-1}$ there exists *I* such that $\omega^{EI}(I) = \omega^{IE}(I) < 1$. In addition, there also exists *I* such that $\omega^{EI}(I) = \omega^{IE}(I) = 1$. Since the functions $\omega^{EI}(I)$ and $\omega^{EI}(I)$ are continuous and because $\omega^{II}(I) < 1$ for all *I* whenever $\delta > 0$, there exists *I* such that $1 > \omega^{EI}(I) = \omega^{IE}(I) > \omega^{II}(I)$. ■

Chapter 4

The Substitutability of Minority and Majority Labor

A significant body of empirical literature finds that minority-majority earnings differential is an increasing function of minority relative size. Some authors argue that this finding is a result of labor market competition among minority and majority individuals, but the direct empirical evidence on the substitutability of minority and majority labor is inconclusive. This chapter investigates the nature of such competition using 2000 U.S. Census-based data. In the framework of generalized Leontief production function, the analysis reveals complementarity of minority and majority labor in production. Imperfect substitutability of minority and majority labor is confirmed in the framework of constant elasticity of substitution production function. These findings support the theories that explain the positive relationship between minority-majority earnings differential and minority share as a labor market outcome. The estimated size of the effects suggests that their importance should be viewed in the context of long-run migration trends that result in large variety of minority concentration across local labor markets.

4.1. Introduction

The notion that minority people take jobs from majority people is widely considered as true by majority people. Yet, minority people often provide specific skills that are highly valued by the larger society. Black basketball magicians amuse the whole world. Gypsy violinists are in high demand in some parts of Europe. Ethnic restaurants operated by minority people have become a part of our gastronomical culture. Taking a more general view, there is empirical evidence that Blacks in the US are overrepresented in some jobs such as public administration. From a less encouraging perspective, minority workers are often found in less skilled jobs.[1] Similar concentration of minority people in certain kinds of education and differences in investment in education between minority and majority people are a persistent feature of many educational systems.[2] These observations suggest that minority people have different human capital and concentrate in different jobs than majority people. Whether these employment and educational regularities result from historical reasons and socio-cultural differences,[3] organization of social interaction in human capital acquisition,[4] or constraints imposed upon minority people by the society[5], they suggest that minority and majority labor is not perfectly substitutable in the labor market. In that case, however, the fiercest competitors of a majority individual in the labor market are other majority individuals and, similarly, minority individuals predominantly compete for jobs held by other minority individuals.

Labor market competition between minority and majority people is not only of popular interest but also has important consequences for the distribution of income. In particular, if minority and majority labor is complementary in production, an increase in the relative number of minority workers increases the marginal product of majority workers and vice versa. As a result, assuming that changes in marginal products are reflected in wages, relative earnings of minority workers vis-à-vis majority workers decrease in the relative

[1] Altonji and Blank (1998), p. 3153.
[2] See e.g. Chiswick (1988).
[3] See Hofstede (1980) and Borjas (1994).
[4] See Kahanec (2004).
[5] The literature on the role of discrimination on economic outcomes includes Becker (1957) and Arrow (1972a, 1972b, 1973, 1998).

number of minority workers, ceteris paribus. Similarly, if minority and majority workers are substitutes rather than complements, an increase in the relative number of minority workers increases their wages vis-à-vis majority workers. For these distributional consequences of imperfect substitutability of minority and majority labor, it is important to understand the nature of substitutability of minority and majority labor in the labor market.

Several studies investigate the substitutability of minority and majority labor. Grant and Hamermesh (1981) study the substitutability of youths, White women, White men, Black adults, and capital in production, estimating a translog econometric model over 67 standard metropolitan statistical areas (SMSAs). They find that Black adults are substitutes for White men and complements to White women and youths in production, although the statistical significance of the relationships of complementarity is low. In a similar framework, Grossman (1982) studies the substitutability of natives and immigrants in production to find that both foreign-born workers and second-generation native workers are substitutes for native workers. Borjas (1983) utilized Diewert's (1971) generalized Leontief approximation to a production function to study substitutability of Black, Hispanic, and White male workers. Borjas suggests that Black male workers may be substitutes for White male workers and finds evidence for complementarity between Hispanic and White male workers. Using a similar methodology, Borjas (1987) investigates the substitutability of White, Black, Hispanic, and Asian male workers by immigrant status over 84 SMSAs. In this study he finds that all immigrant groups are substitutes for native whites; however, this evidence is not robust with respect to endogeneity of supply of labor. Furthermore, he finds that Black natives are substitutes for White natives, but does not find such evidence for Hispanic and Asian natives.

These studies are summarized in Table 4.1. Apparently, the evidence is not conclusive as concerns the substitutability of minority and majority labor. Several results point at substitutability, but some suggest that minority and majority workers are complements. While the variance of results does not permit sensible generalizations as concerns the exact magnitudes or signs of estimated elasticities, the general observation is that the reported elasticities are low and thus that the substitutability of minority and majority labor is relatively high. This result suggests that changes in minority concentration in a labor market as resulting from migration over a short-run have relatively small effects on wages and earnings. However, long run migration patterns may result in large variation of minority concentration across labor markets. To wit, in the US, the percentage of Blacks is about 33 times larger in the 75th percentile than in the 25th percentile school district.[6] Similarly, there are about 10 times more Asians and 22 times more Hispanic per one hundred inhabitants in the respective 75th and 25th percentile school districts. In this context, the effects of even a relatively high substitutability of minority and majority labor may result in substantial variation of distribution of wages, as will be illustrated below.

Table 4.1: The substitutability of minority and majority labor – empirical evidence.

Study	*Econometric Model*	*Data*	*Estimated elasticities of factor prices: The change in the wage of A with respect to the change in the quantity of labor B*	*Separability of capital and labor inputs*
Grant and Hamermesh (1981)	Translog	1/1000 Public Use Sample of the 1970 US Census	Black to White female: 0.0203 Black to White male: -0.0536** White female to Black: 0.0119 White male to Black: -0.0055**	Rejected.
Grossman (1982)	Translog	1970 US Census	Second generation immigrants to natives: -0.39** Foreign-born immigrants to natives: -0.16** Natives to second generation immigrants: -0.15** Natives to foreign-born immigrants: -0.02**	Not rejected.
Borjas (1983)	Generalized Leontief	1976 Survey of Income and Education, 5/100 Sample, US Census Bureau.	$ Black to White: 0.0026/-0.0639** $ Hispanic to White: 0.0234*/0.0353	Not rejected.
Borjas (1987)	Generalized Leontief	1980 5/100 A Sample, US Census	† Black immigrants to White Natives: -0.001**/-0.001 † Hispanic immigrants to White Natives: -0.002**/0.002 † Asian immigrants to White Natives: -0.002**/-0.003 # Black natives to White natives: -1158.6** # Hispanic natives to White natives: -98.5 # Asian natives to White natives: -120.0	No formal test performed. Significant coefficients with the capital input.

Note: ** Significant at 0.01 significance level, * Significant at 0.05 Significance level.
$ Elasticities of complementarity: The change in the relative wage of A with respect to the relative change in the quantity of B, holding the marginal costs and quantities of other factors constant. OLS/IV estimates
# Technology parameters. Negative (positive) sign implies substitutability (complementarity) of inputs.
† OLS/IV estimate.

In the light of these studies, it is interesting to note that there is robust empirical evidence, including the studies by Blalock (1956, 1957), Heer (1959), Brown and Fuguitt (1972),

6 Percentiles in this section refer to ranking of school districts according to Black percentage.

Frisbie and Neidert (1977) and Tienda and Lii (1987), that minority individuals in regions with a higher minority share earn relatively less than minority individuals in regions with a smaller minority share.[7] This evidence, if it is a consequence of labor market competition, points at complementarity of minority and majority labor in production.

The purpose of this study is to empirically investigate the substitutability of minority and majority labor. The ambition is twofold. First, by shedding light on the nature of substitutability of labor of the largest minorities and the White majority in the US this study contributes to the substitutability debate discussed above. Second, resolving whether minority and majority labor is complementary or substitutable in production tells us whether the empirical regularity that relatively larger minorities earn less per efficiency unit of labor than relatively smaller ones is a labor market phenomenon. In this respect, this study contributes to the debate about minority-majority earnings inequality.

This study is perhaps most straightforwardly comparable to Borjas (1983). It differs in three major aspects, however. First, in addition to the White non-Hispanic majority and the Black and Hispanic minorities considered by Borjas, this study accounts for three other major minority groups in the US: Asians, American Indians, and Pacific Islanders. As a result, it covers most labor input in the US labor market. Second, the baseline unit of observation in this study is the school district rather than the individual matched to his or her SMSA. In particular, the ratios of labor supplies of different ethnic groups, the key explanatory variable, are measured at the level of the school district in this analysis, in contrast to that of Borjas, who computes these ratios for SMSAs. Given the large number of school districts, choosing the school district as the unit of observation yields a relatively large variation of this key variable. [8] Third, besides the baseline model similar to that of Borjas, I study an alternative specification of the production function in the constant elasticity of substitution framework.

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[7] This evidence is summarized in the Appendix of Chapter 3, Table 3A.1.

[8] The key question concerning the choice of the unit of observation is what the proper geographic definition of the local labor market is. Sensitivity analysis reveals that the results of this study are robust in this respect. See the discussion in Section 4.3.

Previewing the main results of this study, I empirically establish that the largest US minorities are complementary to the White majority in production and that, as a result, labor market forces disadvantage large minorities in terms of their (relative) earnings per efficiency unit of their labor. This result appears to be robust with respect to a number of alternative specifications of the unit of study, sample, and production technology. To establish this result, I proceed in a number of steps. In the following section I develop the baseline analytical framework of this study. Section 4.3 provides the description of the data. In Section 4.4 I outline the estimation methods and establish the main results. The following section tests the validity of the main results with respect to some alternative explanations and specifications. In the final analytical section I study a single-minority model in the constant elasticity of substitution framework and estimate this elasticity, linking this chapter to the previous one more directly. Then I conclude and suggest issues for further research.

4.2. The Model

To investigate the production relationships among minorities and the majority, I assume a generalized Leontief production function:

$$C = \sum_j \sum_i \beta_{ij} \left(X_i X_j \right)^{1/2} \tag{4.1}$$

where C stands for output, X_i and X_j are, respectively, the quantities of labor inputs of social groups i and j in the labor market and β_{ij} is the technology parameter, which is restricted such that $\beta_{ij} = \beta_{ji}$.[9] Labor inputs i and j are complements whenever $\beta_{ij} > 0$ and substitutes whenever $\beta_{ij} < 0$. Assuming that firms in the labor market operate in a perfectly competitive industry, the system of labor demands derived from the production function (4.1) is:

$$W_i = \beta_{ii} + \sum_{i \neq j} \beta_{ij} \left(X_j / X_i \right)^{1/2}, \tag{4.2}$$

[9] Generalized Leontief production function is a second order approximation to any arbitrary production function and the parametric restriction should be seen as an integral part thereof. See Diewert (1971) for a discussion of the properties of this production function.

where W_i is the wage of individuals from group *i*. This system of labor demands is particularly useful for empirical analysis, as it is linear in parameters β_{ij} and thus can be estimated by conventional least squares methods. The interpretation of β_{ij} is also straightforward: β_{ij} is positive (negative) and the wage of group *i* increases (decreases) in the number of type-*j* individuals per type-*i* individual whenever type-*j* and type-*i* individuals are complements (substitutes) in production. Thus, according to the system of labor demands (4.2), the wage of members of group *i* is affected by the numbers of members of other groups per member of group *i*, X_j / X_i .

A useful transformation of the coefficient β_{ij} is the one that links it to the Hicks partial elasticity of complementarity: $e_{ij} = CC_{ij} / C_i C_j$, where $C_i = \partial C / \partial X_i$ and $C_{ij} = \partial^2 C / \partial X_i \partial X_j$.[10] Namely, it can be shown that under the Generalized Leontief production function the elasticities of complementarity are given by:

$$e_{ij} = \frac{\beta_{ij}}{2\left(s_i s_j W_i W_j\right)^{1/2}} \text{ for } i \neq j$$

and

$$e_{ii} = \frac{\beta_{ii} - W_i}{2 s_i W_i} \text{ for } i = j ,$$

where $s_i = W_i X_i / C$ is the relative share of income accruing to labor input *i*. The Hicks elasticity of complementarity measures the effect of a change in the relative supply of input *j* on the relative price of input *i*, holding the quantities and marginal costs of other inputs constant. A useful property of the elasticity of complementarity is that

$$\frac{d\, ln(W_i)}{d\, ln(X_j)} = s_j e_{ij} .$$

In consequence, these elasticities completely describe the changes in wages resulting from changes in supplies of labor inputs for any given share of income accruing to the respective labor input.

[10] See Hicks (1970).

Estimation of the demand system (4.2) involves three major econometric issues. First, labor force is not necessarily homogenous across labor markets. Certainly, members of group *i* may earn different average wages in some regions than in others not as a result of regional differences in relative supplies of labor inputs, but as a result of variation of their average skills across regions. To solve this issue, I adopt an analogue of the technique customary in the literature.[11] In particular, I assume that the average earnings of members of group *i* in labor market *n*, $E_{i,n}$, depend on (i) the market-determined wage for the average member of group *i* in labor market *n*, $W_{i,n}$, and (ii) the difference $f_{i,n}$ between the average skill level of members of group *i* in labor market *n* and the average skill level of *all* members of group *i*. This difference, $f_{i,n}$, is treated as a fixed effect such that, formally, a representative member of group *i* from labor market *n* earns wage $E_{i,n} = W_{i,n} + f_{i,n}$. It is assumed that $f_{i,n} = Z_{i,n} + \varepsilon_{i,n}$, where $Z_{i,n}$ is the vector of observable characteristics of individuals of type *i* in labor market *n* and $\varepsilon_{i,n}$ is the respective random uncorrelated error. Assuming that in each labor market wages are determined according to the demand system (4.2), it follows that

$$E_{i,n} = \beta_{ii} + \sum_{i \neq j} \beta_{ij} \left(X_{j,n} / X_{i,n} \right)^{1/2} + \beta_i Z_{i,n} + \varepsilon_{i,n} , \qquad (4.3)$$

which is the specification of the system of labor demands used throughout the chapter.

Second, the relative supplies of labor inputs, $X_{j,n} / X_{i,n}$, may be endogenous. Therefore, while in the baseline analysis of Section 4.4 the assumption of inelastic labor supply is adopted, Section 4.5.1 extends the analysis to more complex supply conditions. In particular, I adopt the conventional approach to this problem and address the endogeneity issue in the instrumental variable framework. Finally, although the focus of the analysis is on labor inputs, other inputs such as capital, land, and technology enter production. In the literature, this issue has often been neglected. Scholars who attempt to account for capital admit that the measures of capital that they use are unsatisfactory or of limited use.[12] Land and technology have not been, to my knowledge, addressed in this context.

[11] See Borjas (1983) and Borjas (1987).
[12] See e.g. Grant and Hamermesh (1981), Grossman (1982), Borjas (1983), and Borjas (1987).

Despite the difficulties, in Section 4.5.3 I address this issue and test the robustness of the predictions of this chapter using the degree of urbanization and farming as indicators of capital and land utilization. The analysis is based on the assumption that urbanization (farming) is positively (negatively) related to capital utilization and negatively (positively) to land utilization in production.

4.3. Data

The empirical analysis is conducted on the dataset that contains data about 14,405 school districts of the US, as compiled in the Census 2000 School District Tabulation (STP2) by the National Center for Education Statistics (NCES) of the US.[13] The auxiliary data from the year 1990 are compiled from the SDDB-School District Database (NCES 95-705) as available at the National Bureau for Economic Research.[14] This dataset contains economic and demographic information about the White non-Hispanic majority, hereafter "White," and five minorities: (i) Black or African American, hereafter "Black", (ii) American Indian or Alaska native, hereafter "American Indian," (iii) Asian, (iv) Native Hawaiian or other Pacific Islander, hereafter "Pacific Islander," and (v) Hispanic or Latino. Two points are worth mentioning in regard of this particular partition of the labor force. First, it covers most of the US labor force as identified in the 2000 Census.[15] Second, this partition is appropriate in the light of the main interest of this study and one of the main subjects of the previous two chapters: the substitutability of labor of different ethnic and racial groups. In particular, although further sub-partitions of workers of different ethnicities based on age, immigrant status, and gender certainly deserve further research, they are not the focus of this study. [16]

[13] http://nces.ed.gov/surveys/sdds/c2000.asp.
[14] http://www.nber.org/sddb/.
[15] The two remaining groups not covered here are "Some other race" and "Two or more races".
[16] The NCES dataset does not permit such sub-partitions, except for the one based on gender. See Grossman (1982) and Borjas (1987) for a partition based on immigrant status, Grant and Hamermesh (1981) and Borjas (1987) for a partition based on gender, and Grant and Hamermesh (1981) for a partition based on age.

The school district, a special purpose administration district in the US in which public schools are administered, was chosen as the baseline unit of observation. School districts reflect the organization of social and economic life of the population and thus provide a reasonable geographical representation of the local labor market. Nevertheless, it is necessary to evaluate sensitivity of the results of this study with respect to the choice of the geographical unit of observation. The analysis that was conducted in this matter involved (i) aggregation of school districts into larger geographical units and (ii) estimation of the model only for school districts with relatively large population, thus similar to SMSAs. It turned out that the results reported below are robust with respect to each of these robustness checks.[17]

Table 4.2: Numbers of full-time workers, by race.

Race	*Min*	*Max*	*Mean*	*Median*
All races	8	2,313,825	7,768	2,325
White	0	922,630	4,944	1,685
Black	0	528,105	1,091	55
American Indian	0	11,735	66	14
Asian	0	228,700	457	24
Pacific Islanders	0	27,815	66	10
Hispanic or Latino	0	630,760	855	45

Note: Computed for school districts with positive total population (14,375). Mean and median weighted by the respective populations of workers.

For this study, the most relevant information in the NCES dataset involves earnings and income, educational attainment, employment status and time worked, and age structure of members of each racial and ethnic group mentioned above. The main statistics for the key variables are depicted in Tables 4.2 to 4.4. As one can see, the average school district has 7,768 full-time workers of all races combined, while the median school district has 2,325 full-time workers. The relatively large discrepancy is due to a number of relatively large districts, i.e. 113 school districts have full-time working populations above 100,000 and 6 out of these are above 500,000, but in more than 91 percent of school districts the number of full-time workers is between 100 and 30,000. Table 4.2 also reveals very large

[17] The results of this analysis are not reported. In general, the main results were the same as in the baseline analysis. The first robustness check involved aggregation to the county level, the second sample reduction such that the analysis only involved school districts with population larger than 100,000 inhabitants.

discrepancies between mean and median numbers of minority full-time workers, which suggests concentration of minorities in subsets of school districts.

Table 4.3 depicts that, as concerns median earnings, each minority group earns less than the majority. This is also true for average earnings, with the exception of the Asian minority. The reason that the Asian minority on average earns more and in the median school district less than the White majority is also apparent in Table 4.3: the share of school districts with median earnings above 100,000 US dollars per year is by far the largest for the Asian minority. As concerns the relative standing of minorities vis-à-vis the majority, minority people earn between 33.9 percent less and 2.8 percent more and between 31.8 percent and 2.5 percent less than majority individuals, measured by mean and median earnings, respectively.

Table 4.3: Median earnings of full time workers, by race.

Race	*Percent of school districts with yearly median earnings*		*Median earnings*	
	<2,500	*≥100,000*	*Mean*	*Median*
White	0.01	0.15	36,612	34,768
Black	0.03	0.63	28,255	27,589
American Indian	0.25	0.66	27,125	25,661
Asian	0.14	2.15	37,660	33,900
Pacific Islanders	0.03	0.33	29,714	28,572
Hispanic or Latino	0.13	0.53	24,196	23,729

Note: Computed for school districts with positive total population (14,375). Mean and median weighted by the respective populations of workers. In US dollars.

Finally, in Table 4.4 one can observe that some of the variation of earnings is due to variation in educational levels. In particular, each minority has a lower educational level than the majority, measured by mean and median percentages of respective populations with graduate and undergraduate degrees. The only exception is the Asian minority, which attains a higher educational level than the White majority. The extraordinarily high educational achievement of the Asian minority appears to be the explanation of why its earnings more or less match the earnings of the White majority.

Table 4.4: Percentages of people above 25 with university education.

Race	*Graduate or professional degree*		*Bachelor's degree*	
	Mean	*Median*	*Mean*	*Median*
White	10.04	8.19	17.41	16.04
Black	4.89	4.23	9.63	8.67
American Indian	4.59	0.00	8.31	1.97
Asian	15.99	12.92	26.06	25.18
Pacific Islanders	6.48	0.00	11.23	0.00
Hispanic or Latino	3.86	3.39	7.33	6.36

Note: Computed for school districts with positive total population (14,375). Mean and median weighted by respective populations.

A note concerning the numbers of observations is due before I proceed to the results. While there are 14,375 school districts with positive total population, in the analysis below observations are lost due to two main reasons. First, a large number of observations are lost as a result of the structure of the model. Namely, estimation of a simultaneous equation model with several social groups implies that one can only analyze those school districts that contain *all* these social groups. Second, a relatively small number of observations contain missing information, which precludes their inclusion in the analysis. To illustrate, in the baseline model of the next section that involves the White majority as well as all five minorities, the first restriction reduces the number of school districts to 2,009. Further 66 observations are lost due to missing information, resulting in 1,943 observations included in the baseline model.

To understand the consequences of such reductions of the sample, Table 4.5 lists the basic statistics of the sample of the baseline model. As one can observe comparing Table 4.5 to Table 4.2 and Table 4.3, sample reduction has a minor effect on mean and median earnings. The effect of sample reduction on mean and median numbers of full-time workers is one of a substantial increase of these numbers in the reduced sample. This is a natural consequence of the fact that sample reduction involved elimination of school districts that do not contain workers of each race, which are typically small school districts. Straightforward calculations show, however, that the relative numbers of minority workers between the full sample and the reduced sample are much more similar than the absolute numbers.

Table 4.5: Numbers and median earnings of full-time workers, by race. Districts with all social groups present.

	Number of workers		*Median earnings*	
Race	*Mean*	*Median*	*Mean*	*Median*
White	19,623	9,700	38,312	36,562
Black	3,848	485	28,537	27,883
American Indian	195	74	27,746	26,516
Asian	1,789	270	36,715	33,514
Pacific Islanders	84	14	29,790	28,572
Hispanic or Latino	4,420	760	24,065	23,750

Note: Computed for the 1,949 school districts included in the analysis of Section 4.4. Mean and median weighted by respective populations of workers. In US dollars.

Aggregation of minority groups into one (multiethnic) minority increases the likelihood that at least one of the aggregated minorities is present in a school district, thereby permitting inclusion of more school districts in the analysis. Dropping a minority from the analysis has similar effect. To wit, aggregation of the Asian and American Indian minorities and omitting the Pacific Islanders permits inclusion of 7,878 school districts. Aggregation of all minority groups but the Pacific Islanders permits inclusion of as many as 13,335 school districts.[18] In Section 4.5.2 I investigate this issue further and establish the robustness of the results of the baseline analysis with respect to aggregation of minority groups.

4.4. Estimation Methods and Results

The NCES dataset contains the necessary information for the estimation of the econometric model (4.3). Labor input $X_{i,n}$ is defined as the number of full-time workers from group i that are 15 years old and over. Correspondingly, median earnings of full-time workers older than 15 is the baseline measure of $E_{i,n}$.[19] The vector of observable

[18] It turns out that these aggregations are statistically sensible. See Section 4.5.2.

[19] As an alternative specification, the analysis was redone using the weighted average of median earnings of full-time and part-time workers as the explained variable and the ratios of the numbers of all minority and

characteristics $Z_{i,n}$ comprises educational indicators measuring the percentages of adult members of group *i* in school district *n* with (i) high school diploma, (ii) some college but no degree, (iii) associate degree, (iv) bachelor's degree, and (v) graduate or professional degree.[20] Besides these variables, regional dummies are included in every regression throughout the analysis.[21] The purpose of these dummy variables is to pick the effect of interstate variation in development, infrastructure, climate, and other factors outside the analyzed econometric model that possibly affect the distribution of earnings.

Econometric model (4.3) is estimated using the Zellner's seemingly unrelated regressions (SUREG) estimator, simultaneously imposing cross-equation technological restrictions $\beta_{ij} = \beta_{ji}$ implied by the generalized Leontief technology. Table 4.6 depicts the baseline estimates of the technological parameters.[22] The main result, showing up in colum (1), is that all minorities are complements to the White majority. This result is of substantial interest, as it supports theories of imperfect substitutability of minorities and majorities in the labor market. Furthermore, that minority labor complements majority labor in production suggests that ethnic diversity is beneficial in terms of aggregate output, ceteris paribus. And finally, this result is consistent with the empirical evidence of the direct relationship between minority-majority earnings gap and minority relative size. In particular, complementarity implies that an increase in the relative size of a minority increases majority earnings and decreases the earnings of this minority, holding the sizes of other minorities and the aggregate size of the economy constant. As concerns the technological relationships among minorities, there appears to be a significant complementary relationship between Pacific Islanders and Asians, but all the other

majority workers as the explanatory variable. The results were very similar to those obtained for full-time workers.

[20] Further analysis shows that inclusion of (i) relative numbers of workers that worked full-time less than the whole year by weeks worked and race or (ii) variables depicting the age structure of population by race in the vector $Z_{i,n}$ does not affect the main results.

[21] These dummies represent school districts according to the US Census Bureau Classification: Mid-West East North, Mid-West West North, South Atlantic, South East Central, South West Central, North East New England, North East Mid-Atlantic, West Pacific except Hawaii, West Mountain, and Overseas (Hawaii and Puerto Rico). I joined Hawaii and Puerto Rico to construct the "Overseas" category.

[22] Technological parameters are reported only once; the restriction $\beta_{ij} = \beta_{ji}$ implies that the table of technological parameters is diagonally symmetric.

relationships are insignificant. As concerns the educational variables, they are significant and have expected signs and their magnitudes are ranked as expected.[23]

Table 4.6: Baseline estimates of the technological parameters.

X_j/X_i	*Median earnings of group i, full-time workers* (1)	(2)	(3)	(4)	(5)	(6)
j \ *i*	White	Black	American Indian	Asian	Pacific Islanders	Hispanic or Latino
White						
Black	192.7					
	(5.9)**					
American Indian	167.8	-77.9				
	(4.5)**	(1.1)				
Asian	322.5	-179.9	1.0			
	(6.9)**	(1.8)	(0.0)			
Pacific Islanders	66.4	-74.8	117.2	423.8		
	(2.2)*	(1.5)	(0.6)	(3.4)**		
Hispanic or Latino	184.3	14.8	185.5	201.8	-57.2	
	(4.3)**	(0.2)	(1.8)	(1.5)	(0.9)	
Education (Group *i*):						
High school	17,132	987	7,335	2,612	4,142	6,689
	(3.9)**	(0.5)	(3.7)**	(1.0)	(2.5)*	(3.7)**
College, no degree	1,154	8,192	10,461	2,836	4,885	13,407
	(0.3)	(4.5)**	(5.4)**	(1.1)	(3.0)**	(8.1)**
Associate degree	-4,684	11,195	13,142	12,060	5,973	5,922
	(0.7)	(4.1)**	(4.5)**	(3.1)**	(2.6)*	(1.7)
Bachelor degree	59,341	21,875	16,297	25,783	16,962	31,042
	(17.3)**	(10.6)**	(6.6)**	(10.8)**	(8.3)**	(13.6)**
Graduate or professional degree	52,308	33,044	35,111	55,415	24,445	30,779
	(11.7)**	(12.6)**	(10.8)**	(24.3)**	(10.5)**	(11.8)**
Constant	16,472	25,009	20,080	15,397	23,006	16,918
	(6.4)**	(18.0)**	(12.4)**	(8.6)**	(12.3)**	(20.5)**
R-squared	0.65	0.32	0.15	0.36	0.13	0.36
Observations	1943	1943	1943	1943	1943	1943

Absolute value of z statistics in parentheses
* significant at 5 percent; ** significant at 1 percent

As concerns the interpretation of the baseline results, it is instructive to derive the cross-elasticities of complementarity e_{ij} between the five minorities and the White majority.

[23] In further analysis the parameters with educational variables are not reported.

Because these elasticities depend not only on the technological parameters β_{ij} but also on W_i and s_i, a decision has to be made at what values of W_i and s_i these elasticities are evaluated. Means and medians are the natural evaluation points. Table 4.7 summarizes cross-elasticities of complementarity e_{ij} and elasticities of factor prices $s_j e_{ij}$ between minorities and the majority.

Table 4.7: Cross-elasticity of complementarity and elasticities of factor prices.

	Cross-elasticity of complementarity		*Elasticity of factor prices (Change in the wage of majority with respect to the quantity of minority labor)*		*Elasticity of factor prices (Change in the wage of minority with respect to the quantity of majority labor)*	
	Mean	*Median*	*Mean*	*Median*	*Mean*	*Median*
Black	0.0097	0.0173	0.0010	0.0006	0.0070	0.0155
American Indian	0.0388	0.0406	0.0002	0.0002	0.0280	0.0362
Asian	0.0186	0.0323	0.0012	0.0007	0.0134	0.0288
Pacific Islander	0.0217	0.0343	0.0001	3.4E-5	0.0156	0.0306
Hispanic or Latino	0.0103	0.0155	0.0011	0.0007	0.0074	0.0139

Note: Evaluated at mean and median w_i and s_i of the sample of Table 4.6, 1943 observations.

These elasticities confirm the findings of the previous literature that although they are statistically significant,[24] the effects are not numerically large. As a consequence, short-run migration, which involves relatively small changes in ethnic composition of the labor supply in the local labor market, has relatively small effect on the relative earnings of different ethnic groups.[25] When one compares school districts with markedly different ethnic composition of labor, as resulting from long-run migration patterns, the implied differences in earnings distributions may become substantial, however. To illustrate this, consider the 20th percentile school district that has 9 and the 80th percentile school district that has 199 Black per 1,000 White full-time workers. To estimate the difference in

[24] Concerning the significance levels of the respective technological coefficients from Table 4.6.
[25] Given the variation of the earlier results, direct comparison is almost impossible. Among those results in the previous literature that establish complementarity of minority and majority labor, Borjas (1983) finds the elasticity of complementarity between Hispanic and White labor of about 0.0234, thus slightly higher than my result of 0.0155. Grant and Hamermesh (1981) establish somewhat higher elasticities of factor prices for the substitutability of Black workers with White female workers, but their results were not significant.

Black-White earnings differential between these school districts, let us use the estimate of the technological parameter from Table 4.6. In addition, assume that relative labor input supplies are the only determinants of earnings and that net of their influence workers earn the median earnings of their social group. Given these simplifications, it turns out that Black workers earn about 6.1 percent more (29,687 vs. 27,990 US dollars per annum) and White workers about 0.2 percent less (34,787 vs. 34,868 US dollars per annum) in the 20th percentile than in the 80th percentile school district.[26] This implies a substantial reduction of the Black-White earnings differential from 6,877 to 5,099 US dollars per year, that is, by about a quarter. This example illustrates that even if the effects of migration on earnings over the short run are perhaps numerically unimportant, long-run migration patterns and the resulting changes in the racial composition of labor inputs matter substantially for the distribution of earnings.

4.5. Robustness of the Baseline Results

4.5.1. Supply Side

While in the previous section the assumption of inelastic labor supply was adopted, it is possible that labor input supplies respond to wages. People may decide to migrate for better jobs, to work more (or less) in response to a higher wage, or it may be that people with higher wages can afford better medical care and thus be absent from work less often. Whenever any of these possibilities is operative, labor inputs are endogenous and, as a result, the baseline estimates of Table 4.6 are biased. To account for the possibility of endogeneity of labor inputs, the instrumental variable framework is adopted in this section. In particular, I adopt the three-stage least square method (3SLS) to estimate the technological parameters of the system of demand equations involved in the econometric model (4.3). As above, the technological constraints $\beta_{ij} = \beta_{ji}$ are imposed.

The respective ratios of values of minority populations from the year 1990 are used to instrument $X_{j,n} / X_{i,n}$. The assumption that is made here is that these past ratios are

[26] Similar computations using the estimated elasticities of factor prices lead to a variation of even greater magnitude, leading to the estimates of 32.7 and 1.3 percent, respectively.

related to current earnings through current ratios of labor supplies, $X_{j,n}/X_{i,n}$, but not directly. The assumption that the ratios of past values of minority populations are related to current ratios of labor supplies is capturing the idea that past presence of a minority in a school district attracts immigration of similar people through social relations, that people have incentives to remain in the place of their birth to avoid the costs involved in relocation, and that larger populations contain more workers.[27]

Table 4.8: 3SLS estimates of the technological parameters.

	Median earnings of group i, full-time workers					
X_j/X_i	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
i / *j*	White	Black	American Indian	Asian	Pacific Islanders	Hispanic or Latino
White						
Black	195.3					
	(4.5)**					
American Indian	241.9	-122.4				
	(3.7)**	(1.3)				
Asian	314.8	-327.5	185.8			
	(4.8)**	(2.4)*	(1.1)			
Pacific Islanders	13.6	-86.1	-7.3	206.2		
	(0.2)	(1.3)	(0.0)	(1.1)		
Hispanic or Latino	242.4	-70.4	92.2	-121.8	-79.5	
	(4.0)**	(0.7)	(0.6)	(0.6)	(0.8)	
Constant	19,241	23,450	17,914	17,805	25,892	17,562
	(6.6)**	(15.5)**	(8.4)**	(8.4)**	(8.1)**	(18.8)**
R-squared	0.65	0.33	0.15	0.36	0.10	0.35
Observations	1563	1563	1563	1563	1563	1563

Absolute value of z statistics in parentheses

* significant at 5 percent; ** significant at 1 percent

The most important result of this analysis, summarized in Table 4.8, is that the signs and magnitudes of the coefficients remain very similar to those in Table 4.6.[28] To wit,

[27] The existence of such links is confirmed by the (non-reported) first-step regressions of the 3SLS analysis, where the sets of instruments are statistically significant in each first-step regression. Reduced-form estimation shows that the relationships between explained variables and the exogenous variables are significant and have expected signs.

[28] Note that Table 7 contains about 380 observations less than Table 5. This loss results from missing observations for the instruments.

comparing these two tables, the coefficient in column (1) for the Black minority changes from 192.7 to 195.3 and for the Asian minority from 322.5 to 314.8. In other words, these coefficients almost do not differ whether estimated using the SUREG or 3SLS method. Coefficients with other minorities even somewhat increase in magnitude, in favor of the minority-majority complementarity hypothesis. While the coefficient with Pacific Islanders loses significance, its sign remains positive. These results suggest that the possible endogeneity bias is in general insignificant and the results of the baseline analysis of Table 4.6 are robust in this respect. In other words, it is the demand side that drives the relationship between relative numbers of workers and their earnings.

4.5.2. Aggregation

As mentioned above, one of the issues with estimation of the system of demand equations involved in econometric model (4.3) is that the number of observations is limited by the restriction that only school districts that contain workers of each race can be includes in the analysis. In this section I investigate this issue. In general, from the previous sections it appears that each minority is complementary to the majority, with the exception of the Pacific Islander minority, which seems not have a significant effect on majority earnings. To evaluate the validity of these observations, I test the two hypotheses concerning coefficient restrictions. First, I test the hypothesis that the coefficients β_{ij} for *j* representing American Indians and Asians and *i* representing Whites, Blacks, and Hispanic or Latino are equal and that the corresponding coefficients for *j* representing Pacific Islanders is zero in Table 4.6 and Table 4.8. The test of this hypothesis in the SUREG model of Table 4.6 yields $\chi^2 = 14.88$, thus not rejecting the null hypothesis at 0.01 confidence level. In the 3SLS model of Table 4.8, this hypothesis is not rejected at any conventional confidence level, yielding the test statistics $\chi^2 = 6.38$. Second, similarly, I test the hypothesis that in the models of Table 4.6 and Table 4.8 in column (1) the coefficients β_{ij} where *i* represents the White majority are equal for all minorities *j* except for the coefficient with Pacific Islanders that is zero. The test of this hypothesis in the model of Table 4.6 yields $\chi^2 = 12.86$, which is insignificant at the 0.01 confidence level. Testing the same hypothesis in the model of Table 4.8 yields $\chi^2 = 2.50$ which is insignificant at any conventional confidence level.

Given these results, I impose the abovementioned parametric restrictions one by one on the model and treat the respective minorities as one homogeneous group in the labor market. Aggregation of Asians and American Indians permits inclusion of 7,878 school districts in the analysis, that is, almost four times as many as in the baseline model. The model is estimated using the Zellner's SUREG estimator with the properly defined parametric constraint $\beta_{ij} = \beta_{ji}$. The results are summarized in Table 4.9. As one can observe, the main result remains intact: minorities are complementary to the majority in the labor market. The magnitudes also remain very similar to the baseline model of Table 4.6 and the 3SLS estimates of Table 4.8. The aggregate of Asian and American Indian minorities is also complementary to the majority, although the magnitude of this effect and its significance is not very large. Interestingly, this aggregate appears to be complementary to the Black minority.

Table 4.9: Estimates of the technological parameters.

	Median earnings of group i, full-time workers			
X_j / X_i	*(1)*	*(2)*	*(3)*	*(4)*
i / *j*	White	Black	Hispanic or Latino	Asian or Am. Indian
White				
Black	169.3			
	(8.4)**			
Hispanic or Latino	215.1	43.7		
	(9.5)**	(0.9)		
Asian or Am. Indian	61.7	209.5	-73.2	
	(2.1)*	(3.4)**	(0.8)	
Constant	19,287	22,873	18,900	24,037
	(18.4)**	(33.9)**	(39.5)**	(27.5)**
R-squared	0.70	0.27	0.28	0.30
Observations	7878	7878	7878	7878

Note: Aggregate represents Asians and American Indians.

Absolute value of z statistics in parentheses.

* significant at 5 percent; ** significant at 1 percent

Concerning the second parametric restriction, aggregation of all minorities but Pacific Islanders, who are dropped, permits inclusion of as many as 13,335 school districts in the analysis. Using the same methodology as in the previous aggregation, the estimate of the technological parameter β_{ij} for Whites and Non-Whites is 291.7 with the *z* statistics of 12.3, which is highly significant and in the range of the values estimated in Tables 4.6 and 4.8, where only a smaller sample of school districts was available. Given the similarity of the coefficients estimated in these restricted models to the baseline estimates, it turns out that aggregation strengthens the main prediction of the baseline analysis that minority and majority labor is complementary. [29] These results also suggest, although this deserves further research, that one should not expect markedly different prediction in this respect by aggregating and disaggregating minorities, for example Asians into Japanese, Chinese, Vietnamese, and other Asian ethnicities.

4.5.3. Non-Labor Inputs

As mentioned above, land, capital, and technology typically enter production, alongside labor. Unfortunately, it is impossible to obtain measures of technology and the measures of land and capital are scarce and problematic. Nevertheless, I test the robustness of the baseline predictions with respect to inclusion of variables measuring urbanization and farming intensity, which are, by assumption, correlated to capital and land use. Urbanization and farming intensity are measured as the shares of inhabitants of a school district residing in urban and farm areas, respectively. Similarly as in the case of educational variables, the fixed effects formalization is adopted such that a vector of measures of non-labor inputs is directly introduced into the econometric model (4.3). Again, the Zellner's SUREG estimator is used and $\beta_{ij} = \beta_{ji}$ is imposed.

[29] Given the data available, aggregation also permits 3SLS estimation with the values of the shares of Blacks and all other minorities together in the population from the year 1870 as instruments. This yields the estimate of β_{ij} for Whites and Non-Whites of 363.7 with the z statistics 14.4. This result further supports the complementarity prediction and suggests that even if there was an endogeneity bias, it would work against the complementarity hypothesis and, because of this, the presented estimates of β_{ij} are conservative in this respect.

Table 4.10: Non-labor inputs in production.

	Median earnings of group i, full-time workers					
X_j / X_i	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
i / j	White	Black	American Indian	Asian	Pacific Islanders	Hispanic or Latino
White						
Black	164.1					
	(4.6)**					
American Indian	161.8	-72.7				
	(4.2)**	(1.0)				
Asian	327.5	-139.1	46.2			
	(5.8)**	(1.4)	(0.4)			
Pacific Islanders	62.1	-73.6	52.7	468.0		
	(2.0)*	(1.4)	(0.2)	(3.6)**		
Hispanic or Latino	217.2	-12.9	223.1	166.0	-33.2	
	(4.5)**	(0.2)	(2.1)*	(1.2)	(0.5)	
Non-Labor Inputs:						
Farming Intensity	-25,048	42,615	-43,870	31,056	-33,007	-37,919
	(2.52)*	(2.7)**	(2.30)*	(1.6	(1.2)	(3.2)**
Urbanization	702	1,641	-2,437	2,869	-2,773	-413
	(1.0)	(1.5)	(1.8)	(2.0)	(1.4)	(0.5)
Constant	15,458	23,109	22,274	12,844	25,323	17,867
	(5.8)**	(13.8)**	(11.5)**	(5.5)**	(10.1)**	(15.1)**
R-squared	0.65	0.33	0.16	0.36	0.13	0.36
Observations	1943	1943	1943	1943	1943	1943

Absolute value of z statistics in parentheses

* significant at 5 percent; ** significant at 1 percent

Table 4.10 summarizes the results. One observes that inclusion of the two variables that measure farming intensity and urbanization does not change the estimates of the technological parameters significantly, with reference to the baseline model of Table 4.6. This result supports the robustness of the baseline estimates vis-à-vis presence of non-labor inputs. Both of these variables are significant, however (even for urbanization, which is typically only marginally significant in each regression, exclusion is rejected). Further improvement of the measures of non-labor inputs is necessary in future research, however.

4.6. Constant Elasticity of Substitution

Aggregation of minorities into one category yields another interesting possibility, as mentioned above. Namely, it permits econometric analysis of a two-factor constant elasticity of substitution (CES) model of labor market competition that mirrors the models of Chapter 2 and Chapter 3.[30] In this section I relate the empirical investigation of this chapter to the previous theoretical chapters more straightforwardly, estimating the key parameter thereof. In particular, in this section I estimate the elasticity of substitution between majority labor and the aggregate of the labor input of all minorities but Pacific Islanders, which was constructed in Section 4.5.2. For this purpose, assume that production takes place according to the CES production function:

$$C = \left(\left(\int_0^I X_i di\right)^{(\rho-1)/\rho} + \left(\int_0^J X_j dj\right)^{(\rho-1)/\rho}\right)^{\rho/(\rho-1)},$$

where $\rho > 0$ denotes the elasticity of substitution between minority and majority labor. Assuming a competitive labor market, from this specification it follows that $W_i / W_j = \left(X_j / X_i\right)^{\frac{1}{\rho}}$.[31] Taking the logarithm of both sides and assuming that all factors affecting relative wages in labor market *n* other than $X_{j,n} / X_{i,n}$ are fully accounted of by the fixed-effects approach described in Section 4.2, one obtains a CES econometric model:

$$Ln\left(E_{i,n} / E_{j,n}\right) = \gamma_0 + \gamma_{ij} Ln\left(X_{j,n} / X_{i,n}\right) + \gamma_1 Z_n + \varepsilon_n \qquad (4.4)$$

where Z_n is the vector of factors affecting production and relative wages in particular in labor market *n* and γ_{ij} is the elasticity parameter of our interest that has a convenient interpretation: it is the inverse of the elasticity of substitution ρ.

Table 4.11 summarizes the results of estimation of the CES econometric model (4.4).[32] column (1) presents the OLS estimate of the coefficient γ_{ij} equal to 0.0387. It is

[30] The nonlinearity of the multiple-factor CES models complicates econometric analysis such that conventional estimation methods are unusable.
[31] Note that this result is equivalent to the one obtained in Chapters 2 and 3; the slightly different form facilitates the comparison of the results of this section to those of the previous sections of this chapter.
[32] As above, coefficients with education variables and regional dummies are not reported.

significant at any conventional significance level and its magnitude implies the elasticity of substitution of 25.8. To investigate the possibility of the endogeneity bias, a two-stage least square estimator was computed using the past values of the ratio of White and Non-White populations as instruments from the year 1990. The results summarized in column (2), given their similarity to those in column (1), suggest that the possible endogeneity bias is not severe and that the elasticity of substitution between minority and majority labor is about 25.[33]

Table 4.11: CES estimate of the elasticity of substitution.

	Logarithm of the minority-majority ratio of median earnings, full time workers	
	(1)	*(2)*
Logarithm of the minority-majority ratio of full-time workers	0.0387 (16.7)**	0.0392 (15.3)**
R-squared	0.27	0.27
Observations	9042	8304

Robust t statistics in parentheses
* significant at 5 percent; ** significant at 1 percent

The main message of this section is that it confirms the results obtained in the generalized Leontief framework: minority (majority) relative wage is increasing the in relative number of majority (minority) workers in the local labor market. In other words, it corroborates the finding that minority-majority wage differential is increasing in the share of minority workers in production. It is difficult to compare the magnitudes of the present results with those of Sections 4.4 and 4.5, especially because the cross elasticities of substitution are not constant. One result is robust, however: a relatively large change in labor supplies corresponds to a relatively small change in wages.[34] To conclude, the

[33] The model was estimated also using the 1870 minority-majority population ratio as instrument, yielding the estimate of γ_{ij} equal to 0.109 with the *z* statistics of 7.9, implying the elasticity of substitution of 9.2. This result further supports that there is imperfect substitutability between minority and majority labor and suggest that the estimates of the elasticity of substitution of Table 4.11 are conservative.

[34] Assuming that the minority-majority earnings differential is fully explained by minority percentage, computations show that according to the CES specification and the estimated elasticity coefficient of about 0.04, minority-majority earnings differential is by about one quarter smaller in school districts with minority population 0.9 percent than in those with 19.9 percent of minority workers. This example suggest that the results of this section are comparable to those based on the Generalized Leontief production function, see the example at the end of section 4.4.

estimation of the CES model further supports the hypothesis that minority and majority labor is not perfectly substitutable. Furthermore, it suggests that the empirical evidence that it hurts to be a large minority in terms of relative earnings is, at least partly, a labor market phenomenon.

4.7. Conclusion

Using data from the US labor market, this empirical chapter sheds light on the substitutability of minority and majority labor. In particular, in the generalized Leontief framework, it is empirically established that minority and majority labor exhibit complementarity in production. This result suggests that the findings of the large body of empirical literature that observes a negative relationship between minority relative earnings and minority concentration is a labor market phenomenon. In particular, I argue that concentration of minority workers in the local labor market has a direct and causal negative effect on minority relative wage due to complementarity of minority and majority labor in production. That labor market competition between minority and majority workers generates a negative relationship between relative earnings of minority workers and their proportion in the local labor market is corroborated in the CES framework.

Two issues should be noted concerning the results of this study. First, in the light of earlier studies it appears that the definition of social groups competing in the labor market may affect the result as concerns the estimates of the substitutability of labor. In particular, while this study suggests that minorities are complementary to the majority, other studies show that some subgroups of minority and majority populations, including immigrants, youths, or women, may be substitutes in production. Certainly, the particular partition of the labor force that one adopts is determined by the focus of the particular study. In any case, further research is necessary to elucidate the substitutability of labor of different subgroups of minority and majority people. Second, it is desirable to study the supply side of the labor market in a greater detail. Certainly, one would like to understand the factors that drive migration of minority and majority workers and thus their supply across local labor markets, so that a richer account can be taken of the wage determination process.

Based on the results of this study, it is apparent that the established labor market effects should be evaluated in the context of long-run rather than short-run migration. In particular, the estimated elasticities of complementarity (substitution) between minority and majority workers are relatively small and thus short-run migration should not be expected to affect minority-majority earnings inequality significantly. On the other hand, the study demonstrates that long-run migration patterns that generate substantial variation in ethnic composition of labor markets may significantly affect interethnic earnings distribution.

Chapter 5

Two Faces of the ICT Revolution: Desegregation and Minority-Majority Earnings Inequality

Social interaction is the primary vehicle through which advancement of information and communication technologies (ICT) affects socio-economic outcomes. In the context of minority-majority relations, social distances and segregation determine the benefits individuals gain from social interaction and from improvement of its efficiency. In the general equilibrium framework, this chapter argues that ICT advancement disproportionately increases the efficiency of social interaction in ethnically integrated social networks and that of majority individuals, thereby causing desegregation and increasing interethnic earnings inequality at the same time. The argument thus explains the concurrence of two seemingly contradicting developments in the lives of Black and White Americans since the late 1970s – rising interethnic earnings inequality and desegregation of Blacks. Furthermore, I establish that there is a threshold level of ICT below which all minority individuals prefer segregated neighborhoods and above which some minority individuals choose to integrate, thereby reaping the efficiency benefits of social interaction with the larger society. I interpret the reversal of the segregation trend that occurred in the late 1970s as a consequence of advancement of ICT beyond this threshold level. Finally, I suggest an explanation of why typically no desegregation occurred in extraordinarily segregated areas and in the case of recent immigrants.

5.1. Introduction

Since the late 1970s Americans have been witnessing three major developments in their social and economic life. First, information and communication technologies (ICT), which is the umbrella term that denotes any information processing and communication technology, device, or application, have changed the life of the average American tremendously. What started as face-to-face communication in primeval ages and went through less and more advanced stages such as smoke and drum signals, the alphabet, print and reproduction technologies, and telephone, turned into a sweeping development during the last quarter of the 20th century. The new information and communication technologies that emerged and went mainstream during this so-called ICT revolution include advanced fax and telephony technologies, satellite communication, and computer and network hardware and software, such as word and table processors, e-mail, search engines, and Internet databases and encyclopedias. These technologies immensely improved technological efficiency of interpersonal communication and data processing and storing. In short, the ICT revolution enabled ordinary people to exchange information over large distances at relatively low and still decreasing costs.

Another major development in the context of cohabitation of minority and majority[1] people in the U.S. was the reversal of segregation trends in the late seventies and desegregation of the Black minority thereafter.[2] In particular, while the first three quarters of the 20th century can generally be characterized by increasing degree of segregation, the

[1] Throughout this chapter, similarly as in the previous ones, minority is understood to be a particular racial, ethnic, language, or religious group of individuals who share socio-cultural characteristics such as culture, religion, language, history, beliefs, customs, values, and morals that make them distinct from the rest of the population – the majority. While there may be regions where the minority outnumbers the majority, that minorities constitute smaller proportion of population than majorities is a part of most definitions of the minority. This study does not deal with social groups formed on the basis of occupation, wealth, or other ordinal characteristics.

[2] As in the previous chapters, segregation is understood to be separation of people according to their social, ethnic, racial, religious, or other characteristics in social interaction. Some of the most visible forms of segregation are geographical segregation, as exhibited by e.g. racial segregation of neighborhoods, and social segregation, as found in segregated schools or workplaces. The segregation literature is immense, including DuBois (1899), Myrdal (1944), Taeuber and Taeuber (1965), Massey and Denton (1987, 1993), and Farley and Frey (1994).

last quarter witnessed a steady decline of segregation of the Black minority. [3] Massey and Denton (1987) observe some signs of desegregation of Blacks during the 1970s. Farley and Frey (1994) suggest that segregation between Blacks and Whites started to decline during the 1970s and find pervasive declines of segregation of Blacks during the 1980s. Cutler et al. (1999) provide evidence that segregation of Blacks in the US was increasing since the last decade of the 19th century until the Second World War, it consolidated and expanded between 1940 and 1970, and since the 1970s segregation has been steadily declining.[4]

Finally, although the period after the 1970s has been characterized by desegregation, the socioeconomic gap between ethnic and racial groups has been widening. In particular, following a period of catching up during the 1960s, earnings gaps among racial and ethnic groups have been on the rise since the mid-1970s. While Black men reduced and Black women almost closed the earnings gap during the 1960s when certain antidiscriminatory laws were adopted,[5] the relative earnings of Black men stagnated or somewhat deteriorated and the relative wages of Black women clearly declined since the 1970s, as compared to their White counterparts. Such deterioration was even more pronounced for Hispanic men and women.[6]

Several explanations of desegregation and increasing earnings inequality during the recent decades in the US have been suggested in the literature. Concerning desegregation, Schuman et al. (1985), Schuman and Bobo (1988), and Farley and Frey (1994) argue that the opposition of whites against minority neighbors has been on decline, resulting in a larger number of non-white settlers in “white” neighborhoods and desegregation, in turn.[7] Cutler et al. (1999) argue that it is the elimination of formal barriers to integration that

[3] Two widely used measures of segregation are the indexes of dissimilarity and isolation. The former tells us what share of the minority (or majority) population would need to relocate for the races to be evenly distributed. The latter measures the exposure of minority to majority. See Taeuber and Taeuber (1965), Duncan and Duncan (1955), and Bell (1954).
[4] The evidence is less clear for the Hispanic and Asian minorities, largely due to sizeable recent immigration. See Massey and Denton (1987) and Frey and Farley (1996).
[5] See e.g. Heckman and Payner (1989), Donohue and Heckman (1991), and Neumark and Stock (2001).
[6] Altonji and Blank (1998), p. 3149.
[7] Several scholars, including Farley and Frey (1994), claim that actual levels of resistance against racially mixed living remain high, however.

brought about reversal of segregation trends in the 1970s and caused desegregation thereafter.

In regard of the increasing earnings inequality during the last quarter of the 20th century, Juhn et al. (1991) argue that much of the increase can be explained by the general trend of increasing earnings inequality during this period and the placement of Black workers in the lower end of the earnings distribution. They also establish that part of the increase may be due to racial differences in unobservable school quality. Juhn et al. (1991) and Card and Lemieux (1996) find that changes in returns to skills had a strong negative effect on the Black-White earnings ratio in recent decades. Bound and Freeman (1992) argue that a large fraction of Black-White earnings gap increase can be explained by industrial shifts such as decline in durable manufacturing and regional shifts including changes in metropolitan location. In addition, they also argue that the increase in the supply of young Black college graduates and the resulting deterioration of their wages contributed to the overall increase in Black-White earnings inequality.

The purpose of this chapter is to argue that the concurrence of the three abovementioned phenomena is not coincidental and that there are fundamental causal relationships among them. In particular, I offer a novel explanation of the concurrence of desegregation and increasing earnings inequality, arguing that ICT advancement has two faces in the context of minority-majority social and economic interaction: it contributes to desegregation of minority individuals and drives a wedge between minority and majority earnings. Furthermore, I elucidate why no desegregation occurred in extraordinarily segregated areas and in the case of recent immigrants and offer an explanation why the reversal of the segregation trend occurred in the late 1970s.[8] The arguments are based on the role of social interaction in human capital acquisition and the effects of ICT improvement on social interaction, which I discuss in the next section.

[8] See Cutler et al. (1999) and Cutler et al. (2005).

5.2. The Social and Economic Environment

Social interaction is the prime vehicle through which advancements of communication and information technologies, such as those pertaining to the ICT revolution, affect social organization and economic outcomes. A number of scholars, including Gaspar and Glaeser (1996), Lin (1999), Wellman et al. (1996, 2001), and Feldman (2002) argue that advancements of ICT significantly reduce the costs of exchanging and processing information and make it possible to exchange more complex information, thereby facilitating social interaction. Gaspar and Glaeser (1996) offer several pieces of evidence in support of the positive role of the telephone on social interaction. The positive effect of Internet use on social interaction is supported by empirical studies such as Uslaner (1999), Cole (2000), Hampton and Wellman (2000), and Robinson et al. (2000), who report that Internet users have higher levels of trust and larger social networks. [9] Based on this literature, I adopt the premise that ICT advancement significantly improves the efficiency of social networks and thereby increases the scope and intensity of social interaction.[10]

While technological advancements due to the ICT revolution have facilitated social interaction, there are features of social organization that have constrained it. Segregation is a prime phenomenon of this kind in the context of minority-majority social interaction. It impedes and possibly precludes social interaction between individuals who are segregated and the rest of the society. Another phenomenon that hinders minority-majority social interaction is social distance that encompasses socio-cultural differences between minority and majority individuals, as discussed by e.g. Poole (1927) and Lazear (1999). Difficulties to understand the language, habits, culture, and other characteristics

[9] See also Kraut et al. (1998) and Nie and Erbring (2000), who report that the use of Internet may have detrimental effects on other forms of social interaction, especially for inexperienced and incompetent Internet users.

[10] As in the previous chapters, social network is understood to be a social structure between individual actors that facilitates social interaction among its members.

of the other social group reduce the efficiency of social interaction between socially distant minorities and majorities.[11]

That social interaction in social networks is an important vehicle of human capital acquisition was pointed out by e.g. Allen (1982), Lucas (1988), Ellison and Fudenberg (1993, 1995), and Bala and Goyal (1998).[12] Conley and Udry (2002), Foster and Rosenzweig (1995), and Munshi (2002) argue that social interaction facilitates learning, documenting that farmers learn about the best practices in social interaction with their peers and neighbors. A number of scholars, such as Glaeser et al. (2002), Foster and Rosenzweig (1995), and Lazear (1999), maintain that social interaction in social networks typically involves positive externalities such that the aggregate resources of a network exceed the naïve sum of individual contributions. In line with this literature, I adopt the premise that social interaction is an important input in human capital acquisition that involves external network effects[13] that positively depend on the size of social networks in which skills are acquired.

There are several arguments that the character of environment in which human capital is acquired affects its type and, in particular, that segregated and integrated environments differ with respect to human capital that they support. First, ethnic exclusiveness of segregated social networks gives rise to skill specialization that reflect the purpose of segregated social networks, as compared to integrated social networks that prevail in integrated social networks. If, for example, an ethnic group develops segregated social networks to support their specialization in certain sectors of economy, such as ethnic restaurants or certain crafts,[14] skills available in these social networks differ from those available in integrated social networks. Second, social interaction in segregated social

[11] The main distinction between segregation and social distance is that while segregation is an endogenous feature of societal organization, social distance is the defining socio-cultural difference between minority and majority people.
[12] The literature on social embeddedness of human capital acquisition includes Rees and Schultz (1972), Loury (1977), Bourdieu (1986), and Coleman (1988, 1990).
[13] Network effects arise whenever benefits from a good or service, here the service of social network in skill acquisition process, increase in the number of individuals already owning that good or using that service. One consequence of a network effect is that the use of a network service by one individual indirectly benefits others who use it. This side effect in a transaction is known as network externality.
[14] Well documented is specialization of Gypsy communities in various crafts. See Fraser (1992).

networks is more prone to bear a specific cultural imprint than that in integrated social networks.[15] Finally, to the extent that segregation prevents flow of ideas and innovations and their adoption, segregated social environment perpetuates and supports different skills than integrated one. Ethnic environment, in particular, has spillover effects on the human capital accumulation process and affects the type and quality of skills acquired.[16] Given these arguments, the type of human capital acquired in segregated social networks generally differs from that acquired in integrated social networks. Given this distinction, hereafter "segregated" and "integrated" specify notions, such as labor and wages, pertaining to the respective type of social network and its members.

While segregation may result from external forces such as discrimination, in this chapter I study segregation as a function of the choice of minority people between segregated and integrated social networks. In particular, I focus on the role of an economic factor – earnings under segregation and integration – on individual decision to segregate (integrate). Given the premises developed above it follows that individual choice between segregated and integrated social networks involves two major aspects. First, it entails the wage tradeoff, since the choice between segregation and integration involves choosing between the two different types of human capital to acquire and thus between different wages per efficiency unit of labor supplied. Second, it involves the efficiency tradeoff, as the composition of members of a segregated social network is different from that of an integrated social network and thus, due to social distances and network effects, for any given agent the efficiencies of skill acquisition differ between segregated and integrated social networks.

Corresponding to the wage and efficiency tradeoffs, two mechanisms govern the degree of segregation in the economy on the aggregate level. First, as the share of minority people who choose segregation increases, so does the relative supply of segregated labor. This increase has a negative effect on the relative wage for segregated labor through the textbook substitution mechanism. Second, through the efficiency mechanism, a larger

[15] See Hofstede (1980), Sowell (1994), and Kraus and Hodge (1990).
[16] See Borjas (1994).

number of people in segregated social networks generate larger network effects in these networks. In particular, it improves their relative efficiency vis-à-vis integrated social networks, which suffer a decrease in their size and thus network effects. Under certain conditions, the substitution and efficiency effects give rise to an equilibrium degree of segregation in which for no integrated individual switching to segregation and no segregated individual switching to integration pays off, as segregated and integrated earnings are equal.

The main proposition of this chapter is that advancement of information and communication technologies, such as that pertaining to the ICT revolution, stimulates desegregation of minority individuals and increases minority-majority earnings inequality. The reason why ICT advancement causes desegregation is that it intensifies social interaction and thus increases the weight of the efficiency aspect, which favors desegregation, in the abovementioned tradeoff. On the other hand, ICT improvement favors the majority, as their efficiency gains from the intensified social interaction are larger than those of minority individuals, whose small relative size and social distance to the relatively large number of majority individuals significantly constrain their benefits from the ICT-driven efficiency enhancement.

The argument proceeds as follows. In the next section I develop a general equilibrium model and depict the equilibrium degree of segregation therein. In Section 3 I study the effects of the ICT revolution on equilibrium segregation and interethnic earnings inequality. In Section 4 I offer an explanation why the reversal of segregation trends coincided with the onset of the ICT revolution. Thereafter I summarize and discuss the model and conclude.

5.3. The Model

5.3.1. Demand

To investigate the effects of the ICT revolution on minority-majority segregation and earnings inequality I study an economy populated by the continua of minority and majority individuals with measures *I* and *J* and elements *i* and *j*, respectively. The size of the economy is conveniently normalized to unity such that $I + J = 1$. All individuals are identical with respect to their preferences and endowments, group membership excepting. Individual preferences are represented by a standard utility function $u(\cdot)$ defined on the domain of individual consumption of the consumption good, C_k, where $k \in \{i, j\}$. Let I_{seg} denote the mass of minority individuals that choose segregation and (alone) constitute segregated social networks and I_{int} the mass of those that choose integration and interact with majority individuals in integrated social networks. Thus, $I_{seg} + I_{int} = I$.

Let the consumption good be produced by combining labor inputs of segregated and integrated minority agents, $H_{i,seg}$ and $H_{i,int}$, respectively, and majority agents, H_j, in a perfectly competitive industry according to the constant elasticity of substitution (CES) aggregate production function

$$C = \left(\left(\int_0^{I_{seg}} H_{i,seg} di \right)^{(\rho-1)/\rho} + \left(\int_0^{I_{int}} H_{i,int} di + \int_0^J H_j dj \right)^{(\rho-1)/\rho} \right)^{\rho/(\rho-1)} \tag{5.1}$$

with the elasticity parameter $\rho > 1$. As argued above, labor supplied by segregated minority individuals is an imperfect substitute for labor supplied by majority and integrated minority individuals. For expositional convenience, labor of integrated minority individuals is assumed to be perfectly substitutable with that of majority individuals.

Applying the representative agent hypothesis group-wise and, given the infinitesimal measure of an individual, taking all prices as given on the individual level, production function (5.1) implies that individuals face the following demands for their labor:

$$H_{i,seg} = P_C^{\rho} W_{seg}^{-\rho} C / I_{seg} \tag{5.2a}$$

$$JH_j + I_{int} H_{i,int} = P_C^{\rho} W_{int}^{-\rho} C, \tag{5.2b}$$

where P_C is the price of composite consumption good *C* and W_{seg} and W_{int} are the wages per efficiency unit of labor of segregated and integrated individuals, respectively.[17] As a result of the homogeneity of degree one of the CES production function, the sector does not generate any profits in the equilibrium and one can derive that $P_C = \left(W_{seg}^{1-\rho} + W_{int}^{1-\rho}\right)^{1/(1-\rho)}$.

5.3.2. Supply

On the supply side, taking the actions of other agents and wages as given, individuals aim to maximize their earnings by maximizing the amount of efficient labor they supply on the labor market. In particular, each individual is endowed with one unit of labor time that is, adopting a simplifying assumption, inelastically supplied on the labor market. However, individuals increase the efficiency of their labor by acquiring human capital in social interaction. The labor that they supply in the labor market measured in efficiency units, efficient labor, is then conceptualized to be the product of labor time and human capital.

Minority individuals choose between segregated and integrated social networks to acquire human capital, while all majority individuals are, by assumption, members of integrated social networks.[18] As discussed above, individuals benefit from social interaction with other individuals and these benefits increase in the number of people with whom the particular individual interacts. Furthermore, benefits from social interaction are constrained by segregation and social distance. By assumption, segregated minority individuals do not interact with integrated individuals and vice versa. [19] To capture these assumptions in social interaction, it is assumed that human capital is acquired and thus efficient labor[20] is supplied as follows:

[17] Note here that W_{seg} is the wage of integrated minority as well as majority, whose efficient labors are by assumption perfectly substitutable and thus earn the same unit wage.
[18] In effect, two sets of social networks exist in the economy: segregated ones that involve exclusively minority people who choose to segregate and integrated ones where all majority people and those minority people that chose to integrate interact.
[19] This extreme assumption of zero social interaction between integrated and segregated social groups serves the purpose of exposition and has no bearing on the main results of this chapter.
[20] Because the endowed unit of time is inelastically supplied and efficient labor is the product of labor time and human capital, efficient labor is analytically equal to human capital.

$$H_{i,seg} = 1 + I_{seg}^{\gamma} \tag{5.3a}$$

$$H_{i,int} = 1 + I_{int}^{\gamma} + \frac{1}{1+\delta} J^{\gamma} \tag{5.3b}$$

$$H_{j} = 1 + \frac{1}{1+\delta} I_{int}^{\gamma} + J^{\gamma}, \tag{5.3c}$$

where the parameter $\delta \geq 0$ captures social distance between minority and majority individuals. In particular, benefits from social interaction with socially distant individuals are discounted by the social distance factor $1/(1+\delta)$. Because $\delta \geq 0$, this factor ranges between zero and one. That marginal benefits from social interaction are nonincreasing in the number of interacting people is captured by the parameter γ, where $0 < \gamma \leq 1$. Reasonably, if no social interaction takes place, individual efficient labor is equal to the endowed unit of labor time.

Having delineated fundamental relationships of the economy, I now turn to solving for earnings of segregated and integrated minority individuals and majority individuals, which determine incentives for switching between segregation and integration. Normalizing $P_C = 1$ and using equations (5.2a-b) and (5.3a-c), we solve for wages for segregated and integrated efficient labor to obtain:

$$W_{seg} = \left(\frac{C}{H_{i,seg} I_{seg}} \right)^{\frac{1}{\rho}} \tag{5.4a}$$

$$W_{int} = \left(\frac{C}{H_{j} J + H_{i,int} I_{int}} \right)^{\frac{1}{\rho}}, \tag{5.4b}$$

where C is computed by plugging (5.3a-c) into (5.1) to obtain:

$$C = \left(\left(\left(1 + I_{seg}^{\gamma}\right) I_{seg} \right)^{(\rho-1)/\rho} + \left(\left(1 + \frac{1}{1+\delta} I_{int}^{\gamma} + J^{\gamma}\right) J + \left(1 + I_{int}^{\gamma} + \frac{1}{1+\delta} J^{\gamma}\right) I_{int} \right)^{(\rho-1)/\rho} \right)^{\rho/(\rho-1)}. \tag{5.5}$$

It follows that segregated and integrated minority and majority earnings are, respectively:

$$\Omega_{i,seg} \equiv W_{seg} H_{i,seg} = \left(\frac{C}{\left(1 + I_{seg}^{\gamma}\right) I_{seg}} \right)^{\frac{1}{\rho}} \left(1 + I_{seg}^{\gamma}\right) \tag{5.6a}$$

$$\Omega_{i,int} \equiv W_{int} H_{i,int} = \left(\frac{C}{\left(1 + I_{int}^{\gamma} + \frac{1}{1+\delta} J^{\gamma}\right) I_{int} + \left(1 + \frac{1}{1+\delta} I_{int}^{\gamma} + J^{\gamma}\right) J} \right)^{\frac{1}{\rho}} \left(1 + I_{int}^{\gamma} + \frac{1}{1+\delta} J^{\gamma}\right) \quad (5.6b)$$

$$\Omega_{j} \equiv W_{int} H_{j} = \left(\frac{C}{\left(1 + I_{int}^{\gamma} + \frac{1}{1+\delta} J^{\gamma}\right) I_{int} + \left(1 + \frac{1}{1+\delta} I_{int}^{\gamma} + J^{\gamma}\right) J} \right)^{\frac{1}{\rho}} \left(1 + \frac{1}{1+\delta} I_{int}^{\gamma} + J^{\gamma}\right), \quad (5.6c)$$

where C is defined in equation (5.5).

5.3.3. Equilibrium Segregation

Having formulated the earnings functions of segregated and integrated minority individuals, I am now equipped to study distribution of minority individuals across the two types of social networks and, in particular, the equilibrium degree of segregation in the economy. Recalling that each individual takes the decisions of other agents as given, minority individuals compare earnings under segregation $\Omega_{i,seg}$ and under integration $\Omega_{i,int}$ when deciding what kind of social network to join. Because the costs of switching between social networks are not central to the argument, I assume that switching is frictionless.[21] Under these conditions, segregation equilibrium is characterized by the following equilibrium conditions:

$$\Omega_{i,seg} \geq \Omega_{i,int} \text{ } if \text{ } I_{seg} = I \quad (5.7a)$$

$$\Omega_{i,seg} \leq \Omega_{i,int} \text{ } if \text{ } I_{seg} = 0 \quad (5.7b)$$

$$\Omega_{i,seg} = \Omega_{i,int} \text{ } if \text{ } 0 < I_{seg} < I \text{ } . \quad (5.7c)$$

The first two conditions apply to corner equilibria of full segregation (5.7a) and full integration (5.7b) and say that if all minority individuals choose to segregate (integrate), earnings under segregation (integration) must be at least as high as those under integration (segregation) for each and every minority individual. The last condition

[21] Switching costs can easily be incorporated into the model; this would yield no further insight with respect to the main argument, however.

applies to the case in which some minority segregate and some integrate. Clearly, in such case the economy is in equilibrium if and only if switching does not pay off, that is, if earnings of segregated minority individuals are equal to those of integrated individuals. This is exactly what condition (5.7c) says. Defining $\omega(I_{seg}) \equiv \Omega_{i,seg} / \Omega_{i,int}$ and noting that $\Omega_{int} > 0$, condition (5.7c) is equivalent to $\omega(I_{seg}) = 1$. Upon substitution and straightforward manipulation, $\omega(I_{seg}) = 1$ is equivalent to the following arbitrage condition:

$$\left(\frac{\left(1 + I_{int}^{\gamma} + \frac{1}{1+\delta} J^{\gamma}\right) I_{int} + \left(1 + \frac{1}{1+\delta} I_{int}^{\gamma} + J^{\gamma}\right) J}{\left(1 + I_{seg}^{\gamma}\right) I_{seg}} \right)^{\frac{1}{\rho}} \frac{1 + I_{seg}^{\gamma}}{1 + I_{int}^{\gamma} + \frac{1}{1+\delta} J^{\gamma}} = 1. \qquad \text{(AC)}$$

Because I_{seg} is the only endogenous variable in the arbitrage condition (AC), it fully determines the equilibrium value of I_{seg}, I_{seg}^{e}, and thus the equilibrium share of minority people who segregate in the interior equilibrium.

To depict what kind of interior segregation equilibria can occur in this model, I investigate the properties of $\omega(I_{seg})$ as a function of I_{seg}. Denoting the ratio of human capitals of segregated and integrated minority individuals $h(I_{seg}) \equiv H_{i,seg} / H_{i,int}$ and the ratio of segregated and integrated wages $w(I_{seg}) \equiv W_{seg} / W_{int}$, the function $\omega(I_{seg}) = h(I_{seg}) w(I_{seg})$ is governed by the properties of $w(I_{seg})$ and $h(I_{seg})$, which are driven by efficiency and substitution mechanisms, respectively.

In particular, through the efficiency mechanism, $h(I_{seg})$ increases in the number of segregated minority, that is, $\partial h(I_{seg}) / \partial I_{seg} > 0$. This follows straightforwardly from

$$h(I_{seg}) = \frac{1 + I_{seg}^{\gamma}}{1 + (I - I_{seg})^{\gamma} + \frac{1}{1+\delta} J^{\gamma}} \qquad (5.8)$$

that one obtains by plugging (5.3a) and (5.3b) in the definition of $h(I_{seg})$ above.

It has to be realized, however, that the efficiency mechanism does not necessarily favor integration. In particular, comparing the human capital acquisition technologies (5.3a) and (5.3b), let us state the integration efficiency condition (IEC) under which the efficiency of social interaction of minority individuals is higher in integrated social networks than in segregated ones, that is, $H_{i,seg} < H_{i,int}$:

$$(1+\delta)\left(I_{seg}^{\gamma} - \left(I - I_{seg}\right)^{\gamma}\right) < J^{\gamma}. \qquad \text{(IEC)}$$

This condition holds whenever the number of integrated individuals is sufficiently larger than the number of segregated ones and social distance is not too large, such that for minority individuals the network benefits generated in integrated social networks are higher than those in segregated social networks and integration involves relatively little inefficiency caused by social distance. While this condition depends on the actual degree of segregation I_{seg}, it holds for any I_{seg} whenever $\delta < (J/I)^{\gamma} - 1$. Furthermore, condition (IEC) is more likely to hold if the degree of segregation is relatively small. More specifically, it can easily be seen that there always exists I_{seg} that satisfies condition (IEC) and, in particular, any $I_{seg} < I/2$ does so.

Concerning the substitution mechanism, $w(I_{seg})$ decreases in the number of segregated minority people, that is, $\partial w(I_{seg})/\partial I_{seg} < 0$. This is so because segregating minority individuals increase the supply of segregated human capital and decrease the supply of integrated human capital through two mechanisms. First, the direct effect of increasing segregation on numbers of suppliers of segregated and integrated labor is obvious. Second, there is an indirect effect through which segregation increases per capita supply of human capital of segregated individuals at the expense of integrated individuals through the efficiency mechanism. Given the imperfect elasticity of substitution of segregated and integrated human capitals in production, these supply changes depress segregated wage relative to integrated wage. This readily follows from

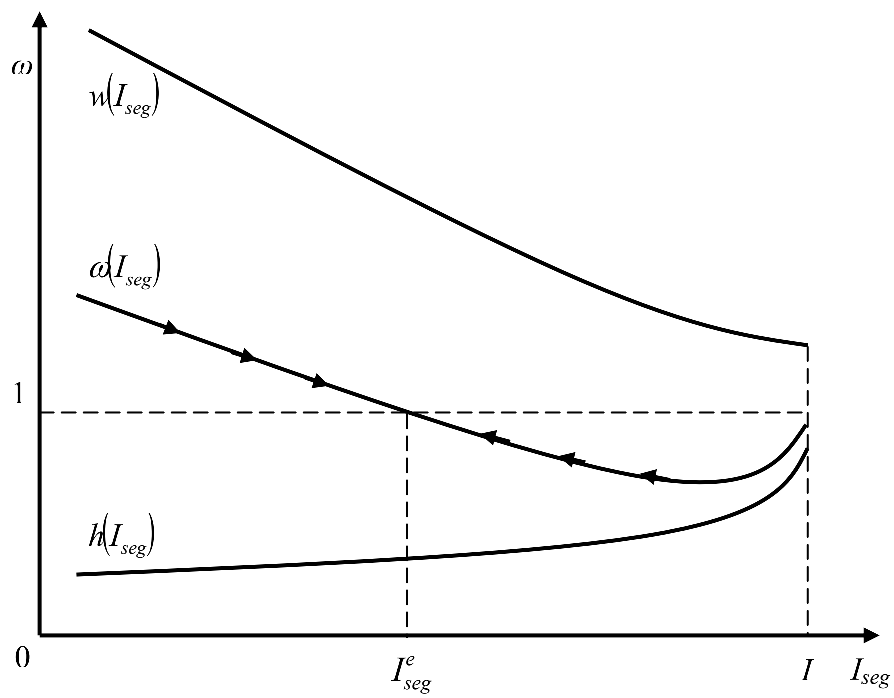
$$w\left(I_{seg}\right)=\left(\frac{\left(1+\left(I-I_{seg}\right)^{\gamma}+\frac{1}{1+\delta}J^{\gamma}\right)\left(I-I_{seg}\right)+\left(1+\frac{1}{1+\delta}\left(I-I_{seg}\right)^{\gamma}+J^{\gamma}\right)J}{\left(1+I_{seg}^{\gamma}\right)I_{seg}}\right)^{\frac{1}{\rho}} \tag{5.9}$$

that is obtained by plugging (5.3a-c) and (5.4a-b) in the definition of $w\left(I_{seg}\right)$. In particular, note that the nominator is decreasing and denominator increasing in I_{seg}.

Therefore, the efficiency and substitution mechanisms work in the opposite directions. It turns out that the elasticity of substitution between segregated and integrated human capitals ρ is the key parameter that governs $\omega\left(I_{seg}\right)$. In particular, while the efficiency mechanism is unaffected by ρ, as apparent form equation (5.8), the strength of the substitution mechanism is decreasing in this elasticity and is not present in the extreme case of perfect substitutability of segregated and integrated labor. This is evident from equation (5.9), where ρ appears in the denominator of the exponent. It follows that ρ determines the relative strength of these two mechanisms and thus the properties of $\omega\left(I_{seg}\right)$.

Figure 5.1 depicts stylized functions $w\left(I_{seg}\right)$ and $h\left(I_{seg}\right)$, reflecting their properties discussed above. The product of these two functions, relative earnings $\omega\left(I_{seg}\right)$, is also depicted in the figure. The position of the $\omega\left(I_{seg}\right)$ curve with respect to the $\omega=1$ line is crucial for the existence of equilibria, since in any interior equilibrium $\omega\left(I_{seg}^{e}\right)=1$. The slope of $\omega\left(I_{seg}\right)$ determines the stability of interior equilibria. In particular, negative slope of $\omega\left(I_{seg}\right)$ in the neighborhood of an interior equilibrium is necessary for its stability, since in such case any deviation from this equilibrium leads to switching of individuals that restores it. This is apparent from the figure, where arrows indicate the response of I_{seg} in disequilibrium states. For example, given that $\omega\left(I_{seg}\right)$ is decreasing in I_{seg} and $\omega\left(I_{seg}^{e}\right)=1$ due to the arbitrage condition, if the deviation within such neighborhood is such that $I_{seg}>I_{seg}^{e}$, then earnings of integrated minority become larger than those of segregated minority, that is, $\omega(I_{seg}) < 1$. If this is the case, however, minority individuals switch to integrated social networks, thereby increasing $\omega(I_{seg})$, until the initial equilibrium is restored. Similar argument explains stability for a deviation below I^e_{seg}. Given these properties of the earnings functions, I now establish the existence of a stable interior equilibrium defined by the arbitrage condition (AC).

Figure 5.1: Interior equilibrium of segregation.



Proposition 1

There always exists some finite $\overline{\rho} > 0$ such that for any finite $\rho > \overline{\rho}$ there exists a stable interior equilibrium $I^e_{seg} \in (0, I)$. Any interior equilibrium satisfies condition (IEC).

Proof in the Appendix.

In particular, no stable interior equilibrium may exist if segregated and integrated labors are perfect substitutes. The reason is that in such case $W_{seg} = W_{int}$ and thus

$\omega(I_{seg}) = h(I_{seg})$, which is, as discussed above, monotonically increasing in I_{seg}. As a result, in any interior equilibrium, which must satisfy $\omega(I_{seg}) = 1$, any disturbance such that $I_{seg} > I_{seg}^{e}$ ($I_{seg} < I_{seg}^{e}$) drives $\omega(I_{seg})$ above (below) one, generating incentives for minority individuals to switch to segregation (integration). Due to monotonicity of $\omega(I_{seg})$, a new equilibrium arises only after all minority individuals have switched to segregation (integration). On the other hand, if ρ is very small, the substitution effect overrides the efficiency effect and segregation is the preferred choice for all minority individuals. In effect, ρ has to be finite such that the substitution effect is operative but sufficiently large such that it is not excessively strong. That all interior equilibria must comply with the (IEC) condition is obvious from the fact that for $I_{seg}^{e} \in (0, I)$ and a finite ρ it holds that $w(I_{seg}) > 1$.[22] Because in any equilibrium $\omega(I_{seg}^{e}) = 1$, it must be that $h(I_{seg}) < 1$, which is exactly the (IEC) condition. The next proposition discusses corner equilibria.

> *Proposition 2*
>
> There always exists some finite $\hat{\rho} > 0$ such that for any finite $\rho < \hat{\rho}$ it holds that $I_{seg} = I$ is a stable equilibrium. Full segregation is also a stable equilibrium whenever condition (IEC) does not hold for $I_{seg} = I$, that is, $\delta > (J/I)^{\gamma} - 1$. Full integration is never an equilibrium, formally, $I_{seg}^{e} > 0$.
>
> *Proof in the Appendix.*

The results stated in Proposition 2 are intuitive. If ρ is sufficiently small, segregated labor is not easily substitutable in production and thus, given the smaller number of minority people, minority individuals receive relatively high wage, which drives them all to segregate. Next, if (IEC) does not hold, the efficiency of social interaction of minority

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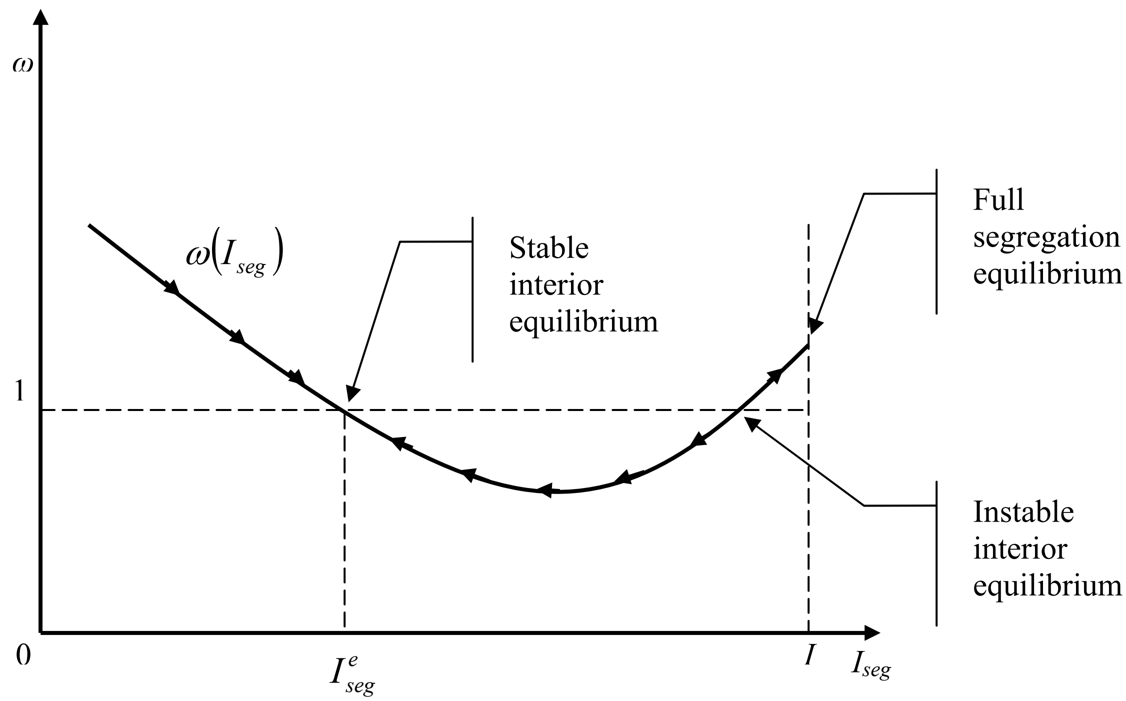
[22] This can easily be verified noting that, since $I < J$, $w(I_{seg})\Big|_{I_{seg}=I} = \left(\frac{(1+J^{\gamma})J}{(1+I^{\gamma})I} \right)^{\frac{1}{\rho}} > 1$.

individuals is lower in integrated social networks than in segregated ones, $h(I_{seg})\big|_{I_{seg}=I} > 1$, and, because $J > I$, under full segregation it also holds that $w(I_{seg})\big|_{I_{seg}=I} > 1$, it must be that $\omega(I_{seg})\big|_{I_{seg}=I} > 1$. That full integration is never an equilibrium follows from the very large incentives to segregate, and thus supply a very scarce type of labor, whenever the number of segregated individuals and thus the degree of segregation are very low.

Figure 5.2: Interior and corner equilibria of segregation.



To fix the ideas, if the elasticity of substitution between segregated and integrated human capitals is large enough, at least one stable interior equilibrium exists in the economy. If this elasticity is small enough or condition (IEC) does not hold under full segregation, there exists a stable equilibrium of full segregation. On the other hand, complete desegregation is never an equilibrium in this model. An interesting question is whether there can be multiple segregation equilibria in the economy. The answer is yes. According to Proposition 1 there always exists an interior equilibrium for ρ sufficiently large. But if condition (IEC) does not hold for $I_{seg} = I$ such that $\delta > (J/I)^{\gamma} - 1$, then it is easy to see that $\omega\left(I_{seg}\right)_{I_{seg}=I} > 1$ for any ρ and a full segregation equilibrium exists as well. Figure 5.2 illustrates these equilibria.

5.4. The ICT Revolution

5.4.1. The Level of ICT and its Role in the Model

Let us now turn to the effects of the ICT revolution on the economy. As mentioned above, advancement of information and communication technologies improves the efficiency of exchanging and processing information. I conceptualize the level of ICT as the likelihood χ, $0 < \chi \leq 1$, that ICT permits social interaction between two randomly chosen individuals who are not separated by segregation. Thus, this probability is a measure of the level of ICT. From the point of view of an individual it is exogenous. Advancement of ICT is operationalized as an increase in χ.[23] It follows that, applying the law of large numbers and noting in (5.3a-c) that any chance to socially interact is valuable and thus taken, a segregated minority individual socially interacts with $I_{seg}\chi$ minority individuals who have chosen to segregate. Similarly, an integrated individual socially interacts with $I_{\text{int}}\chi$ integrated minority individuals and $J\chi$ majority individuals.[24] Parameter χ is accordingly built into equations (5.3a-c), which yields the following modifications of the arbitrage condition (AC):

$$\left(\frac{\left(1+\left(I_{\text{int}}\chi\right)^{\gamma}+\frac{1}{1+\delta}\left(J\chi\right)^{\gamma}\right)I_{\text{int}}+\left(1+\frac{1}{1+\delta}\left(I_{\text{int}}\chi\right)^{\gamma}+\left(J\chi\right)^{\gamma}\right)J}{\left(1+\left(I_{seg}\chi\right)^{\gamma}\right)I_{seg}}\right)^{\frac{1}{\rho}}\frac{1+\left(I_{seg}\chi\right)^{\gamma}}{1+\left(I_{\text{int}}\chi\right)^{\gamma}+\frac{1}{1+\delta}\left(J\chi\right)^{\gamma}}=1. \quad \text{(AC')}$$

[23] It is assumed that ICT technologies symmetrically affect segregated and integrated social networks. This assumption serves the sake of exposition and has no influence on the main argument.

[24] One can now interpret $\left(1/\left(1+\delta\right)\right)^{\frac{1}{\gamma}}$ as the probability that two individuals with social distance δ can socially interact. For the same reasons as in the case of χ, a majority individual interacts with $\left(1/\left(1+\delta\right)\right)^{\frac{1}{\gamma}} I_{int}$ minority individuals and an integrated minority individual interacts with $\left(1/\left(1+\delta\right)\right)^{\frac{1}{\gamma}} J$ majority individuals. Note that in Section 5.3 it is implicitly assumed that $\chi = 1$.

It is worthwhile to note that introduction of χ into the model does not alter the integration efficiency condition (IEC). The reason is that χ affects segregated and integrated social networks symmetrically.

5.4.1.1. Desegregation

Having reformulated the arbitrage condition (AC) such that it implicitly defines I^e_{seg} as a function of χ, I am now equipped to study the effects of the ICT revolution on segregation.

> *Proposition 3*
>
> For any χ, $0 < \chi \leq 1$, and any given I_{seg} such that condition (IEC) holds, there always exists some finite $\tilde{\rho} > 0$ such that for any finite $\rho > \tilde{\rho}$ it holds that $\partial\omega(I_{seg}, \chi)/\partial\chi < 0$. If condition (IEC) does not hold at a given I_{seg}, $\partial\omega(I_{seg}, \chi)/\partial\chi \geq 0$.
>
> *Proof in the Appendix.*

Proposition 3 states that if condition (IEC) holds and segregated and integrated efficient labors are good but imperfect substitutes, improvement in the level of ICT leads to a decrease of the ratio of segregated and integrated earnings and therefore generates incentives to desegregate. In particular, if for minority individuals integrated social networks are more efficient than segregated ones, that is, if condition (IEC) holds, ICT advancement increases the efficiency of integrated social networks more than that of segregated ones. A large enough elasticity of substitution ρ secures that the resulting ICT-driven increase of individual supply of segregated relative to integrated labor is not reversed by the negative effect of this increase on the relative price of segregated labor at the aggregate level. Corollaries 1a, 1b, and 1c straightforwardly follow from Proposition 3:

Corollary 1a

For any stable interior equilibrium I_{seg}^{e} there always exists a finite $\tilde{\rho}$ such that for any finite $\rho > \tilde{\rho}$ an increase in χ instigates desegregation such that the equilibrium level of segregation I_{seg}^{e} decreases.

Corollary 1b

If $I_{seg}^{e} = I$ is a corner equilibrium and satisfies condition (IEC), an increase in χ decreases $\omega(I_{seg})\big|_{I_{seg}=I}$ and

i) leaves the economy at $I_{seg}^{e} = I$, as long as χ is such that $\omega(I_{seg})\big|_{I_{seg}=I} \geq 1$.

ii) causes desegregation, if the increase in χ drives $\omega(I_{seg})\big|_{I_{seg}=I}$ below one.

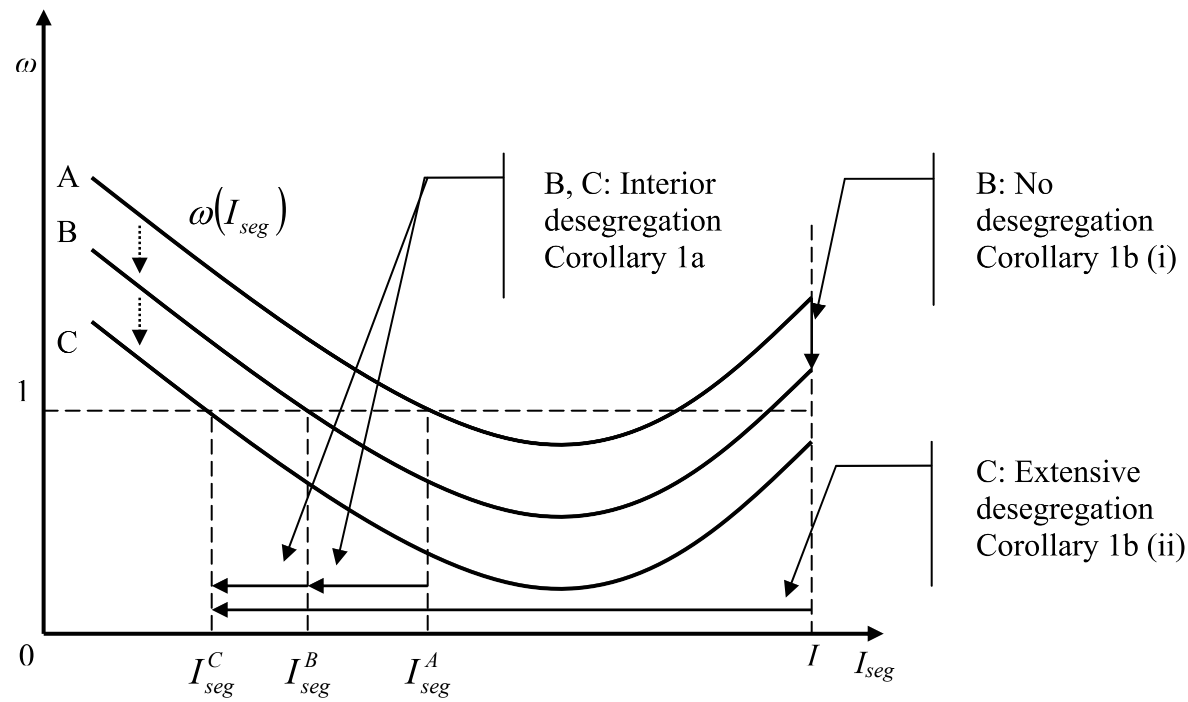
Corollary 1c

Whenever condition (IEC) is not satisfied it holds that $\partial\omega(I_{seg}, \chi)/\partial\chi > 0$ and therefore the degree of segregation remains unchanged in any corner equilibrium of full segregation.

These corollaries describe the effects of ICT improvement on the degree of segregation in the economy. In particular, whenever the economy starts in an interior equilibrium and Black and White efficient labors are relatively well substitutable, ICT improvement brings about desegregation. If the economy starts in a corner equilibrium of full segregation, however, the (IEC) condition is not necessarily satisfied and thus ICT improvement may increase earnings in segregated as compared to integrated social networks, thereby perpetuating full segregation. Moreover, even if the (IEC) condition is satisfied in the corner equilibrium, ICT improvement instigates desegregation only with a delay, as it first needs to close the gap between segregated and integrated earnings.[25] As soon as this occurs, however, desegregation is extensive.

Figure 5.3 illuminates the effects of ICT on the segregation equilibria. From the initial state A, an increase in χ shifts the $\omega(I_{seg})$ curve down to B. Such shift causes desegregation to I_{seg}^{B}, if the economy starts in an interior equilibrium I_{seg}^{A}. If full segregation is the initial state, however, no desegregation occurs. Further increase of χ shifts the $\omega(I_{seg})$ curve down to C and the interior equilibrium shifts from I_{seg}^{B} to I_{seg}^{C}. Unlike in the previous case, however, the shift of the $\omega(I_{seg})$ schedule is so large as to cause desegregation from the full segregation equilibrium to the interior equilibrium I_{seg}^{C}.

Figure 5.3: The effects of χ on equilibrium segregation.



[25] Earnings gap $\omega(I_{seg})\big|_{I_{seg}=I} > 1$ is a sufficient condition for a stable equilibrium of full segregation. If $\partial(W_{seg}/W_{\text{int}})/\partial I_{seg}\big|_{I_{seg}=I} < 0$ and the condition (IE) holds, then $I_{seg} = I$ is a stable corner equilibrium even without an earnings gap, that is, if $\omega(I_{seg})\big|_{I_{seg}=I} = 1$. In such knife-edge case, ICT improvement instigates immediate desegregation from $I_{seg} = I$.

The next proposition states further results of the effects of χ on the economy:

Proposition 4

Whenever $\chi = 0$, the only stable equilibrium is that of full segregation, $I^e_{seg} = I$. Whenever (IEC) holds, there always exists a finite $\widehat{\rho} > 0$ and $\hat{\chi} \in (0,1)$ such that for any $\rho > \widehat{\rho}$:

(i) For any $\chi < \hat{\chi}$ full segregation is a stable equilibrium,

(ii) For any $\chi > \hat{\chi}$ full segregation is not a stable equilibrium and there exists a stable interior segregation equilibrium, $I^e_{seg} \in (0,1)$.

Proof in the Appendix.

Figure 5.4: The effects of χ on the existence of interior and corner equilibria.

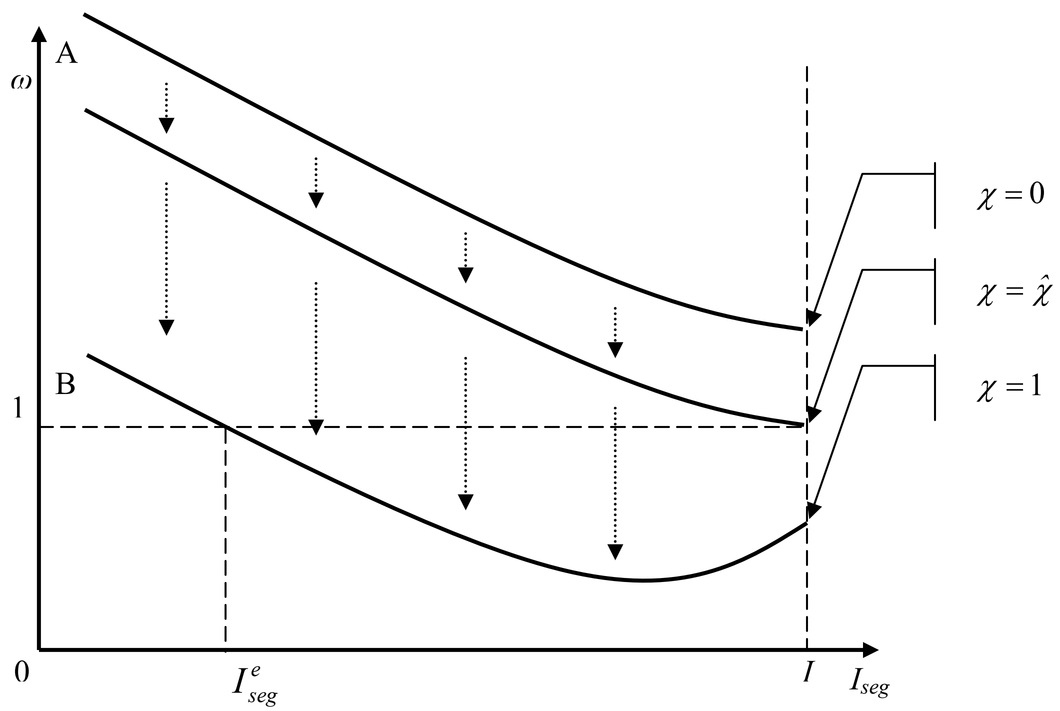


Figure 5.4 depicts stylized patterns of $\omega(I_{seg})$ as determined by the level of ICT χ and elucidates the results depicted in Proposition 4. If $\chi = 0$, the only mechanism that drives the choice between segregation and integration is the choice between segregated and

integrated wages. Because minority is smaller than majority, segregated wage is higher than integrated, and the more so the fewer minority individuals segregate. Therefore, the curve A for $\chi = 0$ is downward sloping and always above the line $\omega = 1$. Clearly, the only equilibrium is that of full segregation. Full segregation remains a stable equilibrium until χ reaches $\hat{\chi}$. After this point, for $\chi \in (\hat{\chi}, 1)$ depicted by curve B, full segregation is not an equilibrium and the economy desegregates towards an interior equilibrium I_{seg}^{e}.

Proposition 4 thus offers an answer why the segregation of the period before the 1970s has been replaced by desegregation thereafter. If the level of ICT is relatively low, the efficiency benefits of integration are minor compared to the wage advantage minority individuals incur if they segregate. As soon as the threshold level of ICT $\hat{\chi}$ is attained, however, the efficiency benefits of integration outweigh this wage advantage and thereby trigger desegregation, which continues until equilibrium between the efficiency benefits of integration and the wage advantage of segregation is restored.

5.4.1.2. Inter-Ethnic Earnings Inequality

Besides affecting equilibrium degree of segregation in the economy, improvements in ICT affect interethnic earnings inequality as well. Primarily, they affect the relative efficiency of segregated and integrated social networks. Next, the resulting changes in supplies of efficient labors affect relative wages of segregated and integrated labors. Finally, given the changes in earnings, switching between segregated and integrated social networks occurs and further affects the efficiencies of human capital acquisition and wages. Assuming that wages respond relatively quickly, I denote the first two responses the short run effect and the response that involves switching between segregation and integration the long run effect. Propositions 5a and 5b state short run results:

Proposition 5a

For any finite ρ and a given $I_{seg} \in [0, I]$, an increase in χ leads to a larger increase in the earnings of majority individuals than integrated minority individuals. That is, $\partial\Omega_j / \partial\chi\big|_{I_{seg}} > \partial\Omega_{i,int} / \partial\chi\big|_{I_{seg}}$.

Proposition 5b

For any interior equilibrium, there always exists some finite $\tilde{\rho} > 0$ such that for any finite $\rho > \tilde{\rho}$ and any given $I_{seg} \in [0, I]$ an increase in χ increases the earnings of majority individuals more than those of segregated minority individuals, that is, $\partial\Omega_j / \partial\chi\big|_{I_{seg}} > \partial\Omega_{i,seg} / \partial\chi\big|_{I_{seg}}$.

Proofs in Appendix.

From Proposition 5a we see that the ICT revolution increases earnings inequality between integrated minority and majority individuals in the short run. The reason is that the relatively small number of integrated minority individuals, as compared to the number of majority individuals, and the social distance between minority and majority individuals constrain the network benefits for integrated minority individuals. Because integrated minority and majority individuals earn the same wage, this efficiency effect fully determines the effects of ICT improvement on minority-majority inequality in integrated social networks. As depicted in Proposition 5b, earnings gap between segregated minority individuals and majority individuals increases as well, if the substitutability of segregated and integrated efficient labors is sufficiently high. Under that condition, the substitution mechanism does not offset the efficiency mechanism through which ICT improvement works in favor of majority individuals, similarly as in Proposition 3. Condition (IEC) is not necessary for these results, because minority is always less efficient than majority in human capital acquisition.

Can, however, desegregation and increasing interethnic inequality coexist in the long run, after desegregation takes place and a new segregation equilibrium arises? Clearly, desegregation reduces the earnings gap between integrated minority individuals and majority individuals, as it improves the relative efficiency of the former in human capital acquisition.[26] Because desegregation continues until earnings of segregated and integrated minority are equalized, desegregation reduces the earnings gap between

[26] This follows straightforwardly from comparison of technologies (5.3b) and (5.3c).

segregated minority and majority as well. In effect, desegregation works against the aggravating effects of the ICT improvement on interethnic earnings inequality. The following proposition states that for sufficiently large J/I, the direct effect of ICT revolution on interethnic earnings inequality outweighs the indirect one that works through desegregation.

Proposition 6

For any interior equilibrium, there always exists some $\bar{y} > 0$ such that for all $J/I > \bar{y}$ and $I_{seg} \in (0,1]$ an improvement in the level of ICT χ causes desegregation and increases interethnic earnings inequality in the long run, that is, $\partial\Omega_j/\partial\chi > \partial\Omega_{i,seg}/\partial\chi$ and $\partial\Omega_j/\partial\chi > \partial\Omega_{i,int}/\partial\chi$.

Proof in the Appendix.

Thus, if the number of majority individuals is sufficiently larger than the number of minority individuals, ICT improvement increases the relative efficiency of majority individuals in skill acquisition so strongly that ICT-driven desegregation does not reverse the tendency of ICT improvement to increase minority-majority earnings inequality.[27]

To summarize this section, in any interior equilibrium ICT improvement in the short run generates incentives to desegregate and increases interethnic earnings inequality. In the long run, minority people desegregate and thereby attenuate earnings inequality. If majority is sufficiently larger than minority, however, the direct effect of ICT improvement on inequality outweighs the indirect long-run effect and desegregation and increasing earnings inequality both occur in the long run.

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[27] In particular, $\partial\Omega_j/\partial\chi > \partial\Omega_{i,seg}/\partial\chi$ and $\partial\Omega_j/\partial\chi > \partial\Omega_{i,int}/\partial\chi$ whenever $\frac{\partial I_{int}/I_{int}}{\partial\chi/\chi} < \left(\frac{J}{I_{int}}\right)^{\gamma} - 1$ or $I_{int} = 0$. $\frac{\partial I_{int}/I_{int}}{\partial\chi/\chi}$ can be interpreted as the elasticity of desegregation with respect to ICT advancement.

5.5. Discussion

5.5.1. Segregation and Earnings Inequality

In this chapter I highlight the role of advancement of information and communication technologies, such as that pertaining to the ICT revolution, in shaping the incentives of minority people to desegregate and in determining interethnic earnings inequality. I argue that the ICT revolution under some conditions increases the incentives of minority to switch to integrated social networks by improving the efficiency of skill acquisition in these social networks relative to segregated ones. These conditions are the more likely to be satisfied the smaller the social distance, the larger the majority as compared to the minority, and/or the smaller the degree of segregation. If the economy is in an interior equilibrium where some minority people integrate and some segregate and if efficient labors of integrated and segregated people are relatively good substitutes, people react to these changed incentives by switching to integrated social networks, that is, desegregating. Desegregation continues until a new segregation equilibrium is restored through the substitution mechanism that depresses the relative wage of integrated individuals until earnings of segregated and integrated minority are equalized.

In the case of complete segregation, however, minority individuals remain segregated even if ICT improvement enhances the efficiency of skill acquisition in integrated social networks relative to segregated ones until the advancement of ICT technologies is large enough to wipe out the initial efficiency advantage of living in segregated social networks. This finding is particularly interesting from the perspective of the findings of Cutler et al. (1999) that in regions with extraordinarily high degrees of segregation desegregation was limited.

ICT improvement increases earnings inequality between integrated minority individuals and majority individuals. The reason is that the efficiency effect favors majority individuals, who are less hurt by social distance as they interact with a relatively small number of socially distant integrated minority individuals. In contrast, integrated minority individuals interact with a relatively large number of socially distant majority individuals. Similarly, ICT advancement favors majority individuals relative to segregated minority individuals, whose social networks are limited in size. Earnings gap widens whenever labors of segregated and integrated individuals are relatively good substitutes, such that an increase in efficiency is not offset by the substitution mechanism that depresses the wage of integrated individuals. In the long run, desegregation works to attenuate the first order effects of ICT advancement on earnings inequality depicted above. Whenever the efficiency advantage of the majority is large enough, however, desegregation does not reverse the main mechanisms through which ICT advancement facilitates desegregation of minority individuals and increases minority-majority earnings inequality.

5.5.2. The Reversal of the 1970s

Based on the aforementioned arguments one can explain the history of segregation and Black-White earnings inequality over the last quarter of the 20th Century in the United States and the concurrence of desegregation and increasing interethnic inequality in particular. Proposition 4 sheds some light on the earlier periods of the 20th Century characterized by increasing segregation of the Black minority and offers an answer to the question what caused the segregation reversal in the 1970s. In particular, I argue that because information and communication technologies were embryonic in the early decades of the 20th century, minority individuals had no incentives to integrate for two reasons. First, upon integration they would be hurt by the increased competition of the larger number of majority individuals on the labor market through the substitution mechanism. Second, the social distance between them and the majority would disadvantage them in integrated social networks in terms of efficiency of skill acquisition. Any migration in that period, driven by these incentives to segregate, increased the aggregate level of segregation.

The gradual advancement of ICT technologies and in particular their massive development since the 1970s, however, offers an explanation of the segregation reversal that occurred at the same time. The rapid increase of the use of communication over the telephone since the 1970s and especially the revolutionary development of the personal computer since the 1980s and mobile telephony and the Internet since the late 1980s, I argue, significantly increased the efficiency of social interaction in larger integrated social networks, as compared to typically smaller segregated social networks. This improvement surpassed the threshold level of ICT below which segregation is superior to integration for minority individuals and stimulated the Black minority to increase their investment in integrated social networks to reap the benefits of the ICT advancement.

5.5.3. The Left-Behinds

While ICT advancement fosters desegregation, certain factors may inhibit or preclude ICT-driven desegregation. First, ICT advancement may not be enough to trigger desegregation in extraordinarily segregated social networks or neighborhoods. The reason is that there the ICT advancement may be insufficient to tip the efficiency tradeoff in favor of integration for an extended period of time, until certain threshold level of ICT is achieved (Proposition 4). Furthermore, ICT-advancement does not favor interaction in integrated social networks whenever social distance between minority and majority individuals is relatively large such that condition (IEC) does not hold, since then the minority does not benefit from interaction with majority individuals in integrated social networks. This may explain the high levels of segregation of recent immigrants, who are typically socially more distant to the majority individuals than incumbent minority individuals. [28]

5.5.4. Social Interaction and the Neighborhood

Given the dramatic development of ICT that annihilates geographical distances as concerns exchange of information, a valid question is whether advancement of ICT eventually makes the neighborhood obsolete. Indeed, there are scholars that suggest that advancement of ICT renders the location of an individual in geographical space immaterial.[29] In this vein, Nie and Erbring (2000) argue that newer technologies of social interaction such as the Internet replace older ones, including face-to-face social interaction, which is by and large locally embedded.

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[28] See Cutler et al. (2005)
[29] See e.g. Toffler (1980), Naisbitt (1995), and Negroponte (1995).

In contrast, other scholars, including Gaspar and Glaeser (1996), Robinson et al. (2000), Hampton and Wellman (2000), and Katz et al. (2001), argue that newer and older technologies of social interaction are complementary. Gaspar and Glaeser (1996) provide a theoretical explanation how ICT advancement gives rise to more social interaction facilitated by both new and old technologies through lowering costs of creating and maintaining a relationship, offering several pieces of evidence to support their theory. Robinson et al. (2000) and Hampton and Wellman (2000) evidence that Internet users are no less active in using media or socializing offline than nonusers. Hampton and Wellman also find that Internet users are acquainted with three times as many of their neighbors than nonusers. Katz et al. (2001) report that Internet users visit friends more often and telephone them more frequently.

Based on this evidence it can be argued that newer and older ICT technologies are complements in social interaction and that advancement of ICT does not make the neighborhood and face-to-face social interaction therein obsolete. In fact, the abovementioned evidence suggests that the importance of the neighborhood increases hand in hand with ICT advancement. Given this complementarity, ICT advancement does not break the link between social interaction and individual location. In particular, ICT advancement not only generates the patterns of (de-)segregation between integrated and segregated social networks discussed in previous sections, but these patterns are reflected in (de-)segregation between segregated and integrated neighborhoods, as evidenced by empirical literature reviewed above.

5.6. Conclusion

This chapter provides an account of the role of the ICT revolution in the history of desegregation and increasing interethnic earnings inequality in the 20th Century in the United States. It explains why ICT contributes to desegregation and how it fuels earnings inequality. It offers an answer why segregation reversal occurred after the 1970s, why extraordinarily segregated neighborhoods remained so, and why recent immigrants experienced high levels of segregation throughout the period. The importance of social interaction in human capital acquisition, social distances, and relative group sizes on these developments are highlighted.

Further theoretical studies should focus on the determination of the level of ICT and formalize the ICT revolution as an outcome of human effort. It would also be interesting to study the direction of ICT innovation in the multiethnic world where information and communication technologies are specific to ethnic groups. Finally, from the empirical perspective, we need further accounts of desegregation and interethnic earnings inequality, e.g. in Europe.

Appendix to Chapter 5

Proof of Proposition 1

Let us first state and prove two lemmas:

Lemma 1

There exists some $\overline{\rho} > 0$ such that for any $\rho > \overline{\rho}$ it holds that $\omega(I_{seg}) < 1$ for some $I_{seg} \in (0, I)$.

Proof: We know that there always exists $I_{seg} \in (0, I)$ that satisfies condition (IEC), that is, $H_{i,seg} < H_{i,\text{int}}$. Combining (5.4a) and (5.4b) to obtain $\frac{W_{seg}}{W_{int}} = \left(\frac{\left(1 + I_{int}^{\gamma} + \frac{1}{1+\delta} J^{\gamma}\right) I_{int} + \left(1 + \frac{1}{1+\delta} I_{int}^{\gamma} + J^{\gamma}\right) J}{\left(1 + I_{seg}^{\gamma}\right) I_{seg}} \right)^{\frac{1}{\rho}}$ and recalling that $I_{int} = 1 - I_{seg}$, it is straightforward to see that $\partial(W_{seg}/W_{\text{int}})/\partial\rho < 0$ and $\underset{\rho\to\infty}{Lim}(W_{seg}/W_{\text{int}}) = 1$ for any given $I_{seg} > 0$. Thus, W_{seg}/W_{int} can be arbitrarily close to one for large enough $\overline{\rho}$ and is closer for all $\rho > \overline{\rho}$. Such $\overline{\rho}$ is implicitly defined by: $\frac{H_{i,seg}}{H_{i,\text{int}}} \left(\frac{H_{i,\text{int}} I_{\text{int}} + H_j J}{H_{i,seg} I_{seg}} \right)^{\frac{1}{\rho}} = 1$ and it is straightforward to see that it always exists. Therefore $\omega(I_{seg}) \equiv \frac{W_{seg}}{W_{\text{int}}} \frac{H_{i,seg}}{H_{i,\text{int}}} < 1$ for some $I_{seg} \in (0, I)$ and all $\rho > \overline{\rho}$. This proves Lemma 1.

Lemma 2

Denote I_{seg}^1 such $I_{seg} \in (0, I)$ where $\omega(I_{seg}^1) < 1$. For any finite $\rho > 0$ there exists $I_{seg} < I_{seg}^1$ such that $\omega(I_{seg}) > 1$.

Proof: From the equation for W_{seg}/W_{int} in the proof of Lemma 1 it is easy to see that $\underset{I_{seg}\to 0}{Lim}(W_{seg}/W_{\text{int}}) = \infty$ and $\partial(W_{seg}/W_{\text{int}})/\partial I_{seg} < 0$ for any $I_{seg} \in (0, I)$. It follows that W_{seg}/W_{int} can be arbitrarily large for some I_{seg} small enough and in particular for some $I_{seg} < I_{seg}^1$. Because $H_{i,seg}/H_{i,int}$ is obviously positive (and finite) for any $I_{seg} \in [0, I]$, this implies that $\omega(I_{seg})$ is larger than 1 for some $I_{seg} \in [0, I]$ and for some $I_{seg} < I_{seg}^1$ in particular. This proves Lemma 2.

Now, since $\omega(I_{seg})$ is continuous in I_{seg} for any $I_{seg} \in (0, I)$ and continuous from the right at $I_{seg} = 0$, Lemma 1 and Lemma 2 imply that there exists some $\overline{\rho} > 0$ as defined in the proof of Lemma 1 such that for any $\rho > \overline{\rho}$ there must be $I_{seg} \in (0, I)$ where $\omega(I_{seg}) = 1$ and $\omega(I_{seg})$ has a negative slope. But these two conditions make it a stable equilibrium. Because it always holds that $W_{seg}/W_{\text{int}} > 1$ and at an interior equilibrium $\omega(I_{seg}) = 1$, it must be that $H_{i,seg}/H_{i,\text{int}} < 1$, which is the (IEC) condition. ■

Proof of Proposition 2

If $\omega(I_{seg})\Big|_{I_{seg}=I} = \left(\frac{(1+J^{\gamma})J}{(1+I^{\gamma})I}\right)^{\frac{1}{\rho}} \frac{1+I^{\gamma}}{1+\frac{1}{1+\delta}J^{\gamma}} > 1$, $I_{seg} = I$ is an equilibrium and the segregated minority individuals have no incentives to deviate (integrate). Obviously, there exists $\hat{\rho} > 0$ such that $\left(\frac{(1+J^{\gamma})J}{(1+I^{\gamma})I}\right)^{\frac{1}{\rho}} \frac{1+I^{\gamma}}{1+\frac{1}{1+\delta}J^{\gamma}} = 1$. And because the left hand side is decreasing in ρ, which is easy to see, for any $\rho < \hat{\rho}$ it must be that $\omega(I_{seg})\Big|_{I_{seg}=I} > 1$. (A knife-edge possibility of a stable corner equilibrium is also that at the same time $\omega(I_{seg})\Big|_{I_{seg}=I} = 1$ and $\partial(W_{seg}/W_{\text{int}})/\partial I_{seg}\Big|_{I_{seg}=I} < 0$.) As concerns full integration, noting that $\underset{I_{seg}\to 0}{Lim}(\omega) = \infty$, there are infinite returns to switching to segregated social network whenever $I_{seg} = 0$. Therefore, $I_{seg} = 0$ is never equilibrium in the model. ■

Proof of Proposition 3

Denote

$$A(\chi) \equiv \frac{1+(I_{seg}\chi)^{\gamma}}{1+((I-I_{seg})\chi)^{\gamma}+\frac{1}{1+\delta}(J\chi)^{\gamma}}$$

$$B(\chi) \equiv \frac{\left(1+((I-I_{seg})\chi)^{\gamma}+\frac{1}{1+\delta}(J\chi)^{\gamma}\right)(I-I_{seg})+\left(1+\frac{1}{1+\delta}\left(((I-I_{seg})\chi)^{\gamma}+(J\chi)^{\gamma}\right)\right)J}{\left(1+(I_{seg}\chi)^{\gamma}\right)I_{seg}}$$

and rewrite the arbitrage condition (AC') as a function of χ at a given I_{seg}:

$$\omega(\chi) = (B(\chi))^{\frac{1}{\rho}} A(\chi) = 1$$

Then differentiate $\omega(\chi)$ (holding I_{seg} constant):

$$\frac{\partial\omega(\chi)}{\partial\chi} = \frac{1}{\rho}(B(\chi))^{\frac{1-\rho}{\rho}} \frac{\partial B(\chi)}{\partial\chi} A(\chi) + (B(\chi))^{\frac{1}{\rho}} \frac{\partial A(\chi)}{\partial\chi}$$

which implies that $\partial\omega(\chi)/\partial\chi < 0$ is equivalent to:

$$\frac{-1}{A(\chi)}\frac{\partial A(\chi)}{\partial \chi} > \frac{1}{\rho}\frac{1}{B(\chi)}\frac{\partial B(\chi)}{\partial \chi} \tag{5A.1}$$

Differentiating $A(\chi)$ with respect to χ one can show that $\frac{\partial A(\chi)}{\partial \chi} < 0$ for any I_{seg} that satisfies condition (IEC), thus in any interior equilibrium in particular. On the other hand, it can be similarly shown that $\frac{\partial B(\chi)}{\partial \chi} > 0$ for any I_{seg}. Obviously, $\frac{\partial A(\chi)}{\partial \chi}$ and $\frac{\partial B(\chi)}{\partial \chi}$ are finite for any positive χ. Moreover, $A(\chi)$ and $B(\chi)$ are both finite and positive. It follows that $\partial\omega(\chi)/\partial\chi < 0$ whenever $\rho > \tilde{\rho} \equiv \frac{A(\chi)}{B(\chi)}\left(\frac{\partial B(\chi)/\partial\chi}{-\partial A(\chi)/\partial\chi}\right)$, where $\tilde{\rho}$ is well defined. It is also easy to see that if condition (IEC) is not satisfied, $\frac{\partial A(\chi)}{\partial \chi} > 0$, therefore inequality (5A.1) cannot be satisfied, and thus $\partial\omega(\chi)/\partial\chi > 0$. ■

Proof of Proposition 4

Recalling the proof of Proposition 3, $A(\chi)\big|_{I_{seg}=I} \equiv \dfrac{1+(I\chi)^{\gamma}}{1+\frac{1}{1+\delta}(J\chi)^{\gamma}}$ and $B(\chi)\big|_{I_{seg}=I} \equiv \dfrac{\left(1+(J\chi)^{\gamma}\right)J}{\left(1+(I\chi)^{\gamma}\right)I}$. Now realize that $\omega(\chi)_{\chi=0,I_{seg}=I} = (J/I)^{\frac{1}{\rho}}$, which is obviously larger than one for any ρ. Moreover, $\omega(\chi)_{\chi=0} = \left(\dfrac{\left(I-I_{seg}\right)+J}{I_{seg}}\right)^{\frac{1}{\rho}}$, which is clearly decreasing in I_{seg}. Therefore, if $\chi = 0$, the only equilibrium is that of full segregation. Now realize that condition (IEC) for $I_{seg} = I$ boils down to $(1+\delta)I^{\gamma} < J^{\gamma}$. For $\chi = 1$, $\omega(\chi)_{\chi=1,I_{seg}=I} = \left(\dfrac{\left(1+J^{\gamma}\right)J}{\left(1+I^{\gamma}\right)I}\right)^{\frac{1}{\rho}} \dfrac{1+I^{\gamma}}{1+\frac{1}{1+\delta}J^{\gamma}}$, which is less than one whenever $\rho > \rho_1 \equiv Log\left(\dfrac{\left(1+J^{\gamma}\right)J}{\left(1+I^{\gamma}\right)I}\right)\Big/ Log\left(\dfrac{1+J^{\gamma}/(1+\delta)}{1+I^{\gamma}}\right)$ and (IEC) holds. Moreover, differentiating $\omega(\chi)_{I_{seg}=I} = \left(\dfrac{\left(1+(J\chi)^{\gamma}\right)J}{\left(1+(I\chi)^{\gamma}\right)I}\right)^{\frac{1}{\rho}} \dfrac{1+(I\chi)^{\gamma}}{1+\frac{1}{1+\delta}(J\chi)^{\gamma}}$, one can show that $\left.\dfrac{\partial\omega(\chi)}{\partial\chi}\right|_{I_{seg}=I} < 0$ for any χ whenever

$\rho > \rho_2 \equiv \left(\left((\chi J)^\gamma - (\chi I)^\gamma \right) \left(1 + \frac{1}{1+\delta} (\chi J)^\gamma \right) \right) \Big/ \left(\left(1 + (\chi J)^\gamma \right) \left(\frac{1}{1+\delta} (\chi J)^\gamma - (\chi I)^\gamma \right) \right)$. Now realize that both ρ_1 and ρ_2 are positive and well defined. Noting that $\omega(\chi)_{I_{seg}=I} = \left(\frac{\left(1+(J\chi)^\gamma\right)J}{\left(1+(I\chi)^\gamma\right)I} \right)^{\frac{1}{\rho}} \frac{1+(I\chi)^\gamma}{1+\frac{1}{1+\delta}(J\chi)^\gamma}$ is continuous in χ, for $\rho > \hat{\rho} \equiv Max|\rho_1, \rho_2|$ there must exist some $\hat{\chi} \in (0,1)$ such that $\omega(\hat{\chi})_{I_{seg}=I} = 1$ and

(i) For any $\chi < \hat{\chi}$ full segregation is a stable equilibrium,

(ii) For any $\chi > \hat{\chi}$ full segregation is not a stable equilibrium and, because $\lim_{I_{seg} \to 0} \left(\omega(I_{seg}) \right) = \infty$ and $\omega(I_{seg})$ is continuous in I_{seg}, there exists a stable interior segregation equilibrium, $I_{seg}^e \in (0,1)$. ■

Proof of Propositions 5a-b

Recalling that $\Omega_j \equiv W_{int} H_j$ and $\Omega_{i,int} \equiv W_{int} H_{i,int}$, $\frac{\partial \Omega_j}{\partial \chi} = \frac{\partial W_{int}}{\partial \chi} H_j + \frac{\partial H_j}{\partial \chi} W_{int}$ and $\frac{\partial \Omega_{i,int}}{\partial \chi} = \frac{\partial W_{int}}{\partial \chi} H_{i,int} + \frac{\partial H_{i,int}}{\partial \chi} W_{int}$. Knowing that $H_j > H_{i,int}$, $\frac{\partial W_{int}}{\partial \chi} H_j > \frac{\partial W_{int}}{\partial \chi} H_{i,int}$. So to establish that $\frac{\partial \Omega_j}{\partial \chi} > \frac{\partial \Omega_{i,int}}{\partial \chi}$ it suffices to show that $\frac{\partial H_j}{\partial \chi} > \frac{\partial H_{i,int}}{\partial \chi}$. Noting that $H_{i,int} = 1 + (I_{int}\chi)^\gamma + \frac{1}{1+\delta}(J\chi)^\gamma$ and $H_j = 1 + \frac{1}{1+\delta}(I_{int}\chi)^\gamma + (J\chi)^\gamma$, $\frac{\partial H_{i,\text{int}}}{\partial \chi} = \gamma (I_{\text{int}}\chi)^{\gamma-1} I_{\text{int}} + \frac{1}{1+\delta}\gamma (J\chi)^{\gamma-1} J$ and $\frac{\partial H_j}{\partial \chi} = \frac{1}{1+\delta}\gamma (I_{\text{int}}\chi)^{\gamma-1} I_{\text{int}} + \gamma (J\chi)^{\gamma-1} J$. After some straightforward algebraic manipulation one can show that because $J > I_{\text{int}}$ and $\delta > 0$ it must be that $\partial H_j / \partial \chi > \partial H_{i,\text{int}} / \partial \chi$ and thus $\partial \Omega_j / \partial \chi > \partial \Omega_{i,\text{int}} / \partial \chi$. To compare $\frac{\partial \Omega_j}{\partial \chi}$ and $\frac{\partial \Omega_{i,seg}}{\partial \chi}$, noting that segregated minority and majority do not receive the same wage, it is necessary to proceed as in the proof of Proposition 3 where the only change is that $A(\chi)$ is redefined: $A'(\chi) \equiv \frac{1+\left(I_{seg}\chi\right)^\gamma}{1+\frac{1}{1+\delta}\left(\left((I - I_{seg})\chi\right)^\gamma + (J\chi)^\gamma\right)}$. All the rest of the proof of Proposition 3 applies here, the only exception being that it always holds that $\frac{\partial A(\chi)}{\partial \chi} < 0$ and thus condition (IEC) is not necessary. This implies that $\partial \Omega_j / \partial \chi > \partial \Omega_{i,\text{int}} / \partial \chi$ whenever ρ is large enough such as in the proof of Proposition 3 with $A'(\chi)$ instead of $A(\chi)$ and the respectively redefined $\tilde{\rho}$. ■

Proof of Proposition 6

Differentiating equations (3b) and (3c) with respect to χ and realizing that I_{seg}^{e} is also a function of χ in the long run, one obtains:

$$\frac{\partial H_{i,int}}{\partial \chi} = \frac{\gamma (J\chi)^{\gamma-1} J}{1+\delta} + \gamma (I_{int}\chi)^{\gamma-1}\left(I_{int} + \frac{\partial I_{int}}{\partial \chi}\chi \right)$$

$$\frac{\partial H_{j}}{\partial \chi} = \gamma (J\chi)^{\gamma-1} J + \frac{\gamma (I_{int}\chi)^{\gamma-1}}{1+\delta}\left(I_{int} + \frac{\partial I_{int}}{\partial \chi}\chi \right).$$

From these results one obtains that $\partial H_{j}/\partial \chi > \partial H_{i,\mathrm{int}}/\partial \chi$ is equivalent to the condition $\frac{\partial I_{\mathrm{int}}/I_{\mathrm{int}}}{\partial \chi/\chi} < \left(\frac{J}{I_{\mathrm{int}}} \right)^{\gamma} - 1$, for any positive I_{int}. If $I_{int} = 0$, one can easily see from the derivatives above that $\partial H_{j}/\partial \chi > \partial H_{i,\mathrm{int}}/\partial \chi$, because $\delta > 0$. Clearly, only desegregation ($\partial I_{\mathrm{int}} > 0$) can violate this condition, given that $\partial \chi > 0$. Because $\partial \omega(\chi)/\partial \chi$ and $\partial \omega(I_{seg})/\partial I_{seg}$ are non-zero and finite for any $I_{seg} > 0$ and $\chi > 0$, which is obvious from inspection of $\omega(\chi)$ above, $\partial I_{seg}/\partial \chi = -\frac{\partial \omega(I_{seg},\chi)/\partial \chi}{\partial \omega(I_{seg},\chi)/\partial I_{seg}} = -\partial I_{\mathrm{int}}/\partial \chi$ is finite as well. But then there for any $I_{int} \in (0, I)$ and $0 < \chi \leq 1$ there exists $\bar{y} > 0$ such that for any $J/I > \bar{y}$ the condition $\frac{\partial I_{int}/I_{int}}{\partial \chi/\chi} < \left(\frac{J}{I_{int}} \right)^{\gamma} - 1$ is satisfied. As in the previous proof, $\partial H_{j}/\partial \chi > \partial H_{i,\mathrm{int}}/\partial \chi$ implies $\partial \Omega_{j}/\partial \chi > \partial \Omega_{i,\mathrm{int}}/\partial \chi$. Because the arbitrage condition (AC) holds in the long run and thus $\Omega_{i,\mathrm{int}} = \Omega_{i,seg}$, $\partial \Omega_{j}/\partial \chi > \partial \Omega_{i,\mathrm{int}}/\partial \chi$ implies that $\partial \Omega_{j}/\partial \chi > \partial \Omega_{i,seg}/\partial \chi$. ■

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Samenvatting (Summary in Dutch)

De interactie tussen etnische groepen, die onderling verschillen in taal, religie en andere sociaal-culturele opzichten, heeft met enkele intrigerende kenmerken de aandacht van sociologen en economen getrokken. Dit proefschrift stelt twee paradoxale empirische verschijnselen centraal. Het eerste is wat ik de *schaalpuzzel* noem: minderheden verdienen in het algemeen een lager inkomen per hoofd dan gemiddeld in de bevolking, maar tevens stijgt de ongelijkheid naarmate de minderhedengroep een groter aandeel in de totale bevolking van een bepaalde regio uitmaakt. Het tweede empirische verschijnsel betreft *segregatie en inkomensongelijkheid*. Een belangrijke tendens in regio's in de Verenigde Staten waar witte en zwarte bevolking samenleven, is de ommekeer in segregatietrends aan het einde van de jaren zeventig en desegregatie van de zwarte bevolking vanaf die tijd. In dezelfde periode is de inkomensongelijkheid tussen de twee groepen toegenomen. Dit lijkt paradoxaal, aangezien het voor de hand ligt te redeneren dat desegregatie hand in hand gaat met juist vermindering van inkomensongelijkheid. Het doel van dit proefschrift is de genoemde twee empirische puzzels te verklaren en zo het inzicht te vergroten in de complexiteit van sociale en economische interactie tussen minderheden en de rest van de bevolking.

Het analytische deel van het proefschrift begint in hoofdstuk 2, waar ik een archetypisch model presenteer voor de interactie tussen een als minderheid te typeren bevolkingsgroep ('minority') en de – als eenheid te beschouwen – rest van de bevolking ('majority') bij het verwerven van vaardigheden ('human capital') en op de arbeidsmarkt. Dit model presenteert in gestileerde vorm de belangrijkste variabelen en argumenten die in dit proefschrift centraal staan. Bovendien stelt het mij in staat een eerste visie te geven op de rol van *lokale effecten* en *sociale afstand* in sociale interactie, met name de verbanden die deze teweegbrengen tussen sociale interactie, productiemiddelen en lonen.

Het belangrijkste inzicht in hoofdstuk 3 is dat imperfecte substitueerbaarheid tussen vaardigheden van verschillende bevolkingsgroepen een directe consequentie kan zijn van lokale spillover effecten in het proces waarin vaardigheden worden verworven en van sociale afstand bij sociale interactie. In dit hoofdstuk ga ik uit van een situatie waarin heterogene vaardigheden worden verworven in specifieke sociale netwerken. Ik laat zien dat lokale effecten en sociale afstand leiden tot systematische verschillen in de efficiëntie waarmee vaardigheden kunnen worden opgedaan. De opbrengsten van het investeren in te onderscheiden vaardigheden verschillen hierdoor tussen bevolkingsgroepen, wat de feitelijke keuze tussen deze vaardigheden beïnvloedt. Afhankelijk van het specifieke evenwicht dat tot stand komt, zullen verschillende bevolkingsgroepen terechtkomen in andere sociaal-culturele netwerken, waardoor minderheden andere vaardigheden opbouwen dan de rest van de bevolking. De verschillende vaardigheden worden ongelijk beloond op de arbeidsmarkt omdat ze imperfecte substituten zijn. Ik laat zien in hoofdstuk 3 dat het lokale spillovereffect en de resulterende arbeidsspecialisatie van etnische groepen de schaalpuzzel kan verklaren. Bovendien geeft dit hoofdstuk een mogelijke verklaring waarom sommige minderheden juist meer verdienen dan andere groepen, waarom minderhedengroepen relatief meer tijd besteden binnen de familie, en waarom integratie grotere ongelijkheid kan brengen voor minderheden.

Hoofdstuk 4 valideert in empirische zin een essentiële aanname uit hoofdstuk 3. Ik beargumenteer daar, kort gezegd, dat het positief verband tussen minderheden (als percentage van de bevolking) en inkomensongelijkheid (gemeten als verhouding tussen het gemiddelde loon van de rijke bevolkingsgroep ten opzichte van dat van de minderhedengroep) tot stand komt op de arbeidsmarkt en voortvloeit uit de imperfecte substitueerbaarheid van vaardigheden die de verschillende bevolkingsgroepen hebben verworven. Het empirische hoofdstuk 4 onderzoekt deze aanname van imperfecte substitueerbaarheid, gebruikmakend van data over de arbeidsmarkt in de Verenigde Staten. Ik baseer me allereerst op het model van de gegeneraliseerde Leontief productiefunctie, wat me toestaat kruislingse complementariteitselasticiteiten te schatten voor de arbeid van verschillende minderhedengroepen. Daarnaast schat ik een model van concurrentie op de arbeidsmarkt waarin ik veronderstel dat substitutie tussen arbeid van verschillende bevolkingsgroepen gekenmerkt wordt door een constante substitutie-elasticiteit. De analyse verwerpt de nul-hypothese dat arbeid van minderheden en van de rest van de bevolking perfecte substituten zijn op de arbeidsmarkt. Meer specifiek wijst de analyse uit dat de arbeid van minderheden complementair is aan de arbeid van de rest van de bevolking en omgekeerd, en dat de substitutie-elasticiteit tussen de verschillende soorten arbeid eindig is. Hiermee ondersteunt hoofdstuk 4 de theorie dat verschillende minderheden andere vaardigheden hebben verworven en andere soorten arbeid aanbieden dan de rest van de bevolking. Bovendien suggereren de bevindingen dat de arbeidsmarkt verantwoordelijk is voor de schaalpuzzel, namelijk het empirische fenomeen dat relatieve inkomensongelijkheid van minderheden stijgt met het percentage van minderheden in een regio.

In hoofdstuk 5 concentreer ik me op twee elkaar schijnbaar tegensprekende ontwikkelingen in het leven van Amerikanen in het laatste kwart van de twintigste eeuw: (i) de segregatie van zwarten en (ii) de toenemende interetnische inkomensongelijkheid. Om de mechanismen achter deze ontwikkelingen te verklaren bestudeer ik in een analytisch model hoe individuen in de minderhedengroepen beslissen met wie een sociaal verband aan te gaan: gaan zij alleen met hun eigen groep om of ook met de andere groep? Daarna bestudeer ik binnen dit model de rol van verbeteringen in informatie- en communicatietechnologieën (ICT) op hun keuze en laat zien hoe deze verbeteringen de genoemde waargenomen empirische tendensen kunnen verklaren. In het bijzonder stel ik dat ICT-verbeteringen disproportioneel de efficiëntie verhogen van (i) sociale interactie in geïntegreerde netwerken en (ii) individuen die tot een grote groep behoren. Dit heeft tot gevolg dat ICT-verbeteringen desegregatie veroorzaken en tegelijkertijd de interetnische inkomensongelijkheid vergroten. Bovendien leid ik in dit laatste hoofdstuk af dat er een drempelniveau is voor de productiviteit van ICT dat de segregatiekeuze bepaalt. Is ICT productiever dan het drempelniveau, dan kiezen alle individuen van een minderheid ervoor in een gesegregeerde gemeenschap te leven; is ICT productiever dan het drempelniveau, dan kiezen sommige, maar niet alle, individuen voor segregatie. Ik beargumenteer dat de ommekeer in de tendens tot segregatie die plaatsvond aan het einde van de jaren 70 van de twintigste eeuw een uiting kan zijn van het overschrijden van deze drempel. Tenslotte toon ik aan dat een substantiële verbetering in ICT nodig kan zijn voor het uitlokken van desegregatie in het geval een regio sterk is gesegregeerd en dat verbetering in ICT segregatie juist kan versterken als de minderhedengroep sterk afwijkt van de rest van de bevolking. Deze theoretische bevindingen geven een verklaring waarom in het algemeen geen desegregatie plaatsvond in gebieden die extreem sterk gesegregeerd waren en ook niet bij mensen die recent zijn geïmmigreerd en daarom minder aansluiting vinden bij de bevolking dan het geval is voor minderheden die zijn geboren in de regio waar zij wonen.

De belangrijkste resultaten in het proefschrift kunnen als volgt worden samengevat. Ten eerste vinden we dat we verschillen in typen vaardigheden en hoeveelheid "human capital" die worden verworven door de verschillende bevolkingsgroepen, minderheden en de rest, kunnen modelleren door lokale spillover effecten en als gevolg van sociale afstand. Deze effecten kunnen een persistente uitwerking hebben op de wijze waarop minderheden hun plaats in de maatschappij krijgen. Zo lang als sociale afstand tussen minderheden en de rest van de bevolking blijft bestaan waardoor de minderheden als aparte sociaal-culturele groepen moeten worden beschouwd, zullen sociale en economische krachten deze verschillen en de consequenties ervan in stand houden, en zal inkomensongelijkheid blijvend positief gerelateerd zijn aan de relatieve omvang van de minderhedengroep.

Ten tweede vinden we op grond van de analytische modellen belangrijke relatieve inkomenseffecten van integratie. Enerzijds zal de integratie van minderheden voor iedereen voordelig zijn: het wordt gemakkelijker vaardigheden te verwerven en 'human capital' op te bouwen omdat uitwisseling van ideeën gemakkelijker wordt. Anderzijds kan de inkomensongelijkheid door integratie toenemen, omdat minderheden nu op de arbeidsmarkt concurreren met een grotere groep. Bij segregatie concurreren leden van de minderhedengroep voornamelijk met de andere leden van diezelfde groep, en hun aantal is relatief klein ten opzichte van de totale bevolking. Bij integratie daarentegen verwerven minderheden vaardigheden die meer vergelijkbaar zijn met die van de rest van de bevolking en concurreren ze voornamelijk met een relatief groot deel van de bevolking. Daarom zal integratie weliswaar leiden tot meer 'human capital' maar ook tot een grotere blootstelling aan concurrentie op de arbeidsmarkt waardoor de lonen van minderheden per eenheid 'human capital' zullen dalen. In het geval dat integratie het relatieve loon van minderheden meer laat dalen dan het de relatieve hoeveelheid 'human capital' laat stijgen, dan zal integratie de inkomensongelijkheid van minderheden ten opzichte van de rest van de bevolking laten stijgen.

Ten derde bevestigt het empirische onderzoek in hoofdstuk 4 de visie dat arbeid van minderhedengroepen als productiefactor imperfect substituteerbaar is met arbeid van de rest van de bevolking. Dit ondersteunt echter niet de vaak uitgesproken vrees dat werkers uit minderhedengroepen de banen van andere werkers verdringen. Het empirische onderzoek toont aan dat een multi-etnische beroepsbevolking voordelen brengt en dat de rest van de bevolking baat heeft bij de aanwezigheid van werkers uit minderhedengroepen.

Ten vierde, tenslotte, maakt dit proefschrift enkele voordelen en kosten expliciet van de verbeteringen in informatie- en communicatietechnologie (ICT). In de modelmatige analyse leidt een ICT-verbetering tot efficiëntere verwerving van 'human capital', die iedereen bevoordeelt. Bovendien leidt het tot de-segregatie van minderheden, aangezien de voordelen van de efficiëntieverbeteringen vooral ten goede komen aan individuen die kiezen voor leven en leren in een geïntegreerde groep. Echter, ICT-verbeteringen werken niet symmetrisch uit op de efficiëntie van het verwerven van 'human capital': vooral grote groepen winnen, waardoor minderheden relatief weinig winnen en de relatieve inkomensongelijkheid toeneemt ondanks de verminderde segregatie.